APPENDIX J

Water Quality Technical Materials

San Francisco Bay Area Environmental Management Plan

June 1981

This plan was prepared by the Association of Bay Area Governments with a grant and other assistance from the Environmental Protection Agency, in cooperation with Bay Area Air Pollution Control District, Metropolitan Transportation Commission, San Francisco Bay Regional Water Quality Control Board and Counties of the Bay Area

ABAG

APPENDIX J

SAN FRANCISCO BAY AREA WATER QUALITY MANAGEMENT PROGRAM

TECHNICAL MEMORANDA NUMBERS 34 THROUGH 59

FROM THE 1979-80 WATER QUALITY PLANNING PROGRAM

OCTOBER 1981

ABAG
Association of Bay Area Governments
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WATER QUALITY MANAGEMENT PLAN

LIST OF TECHNICAL MATERIALS

WQMP/TECHNICAL MEMORANDA

- Technical Memorandum 34 - "Grading Ordinances and Surface Runoff Control," Novemeber 1979.
- Technical Memorandum 35 - "Street Surface Pollutant Accumulation and Removal," September 1980
- Technical Memorandum 37 - "Watercourse Protection Ordinances," November 1979
- Technical Memorandum 38 - "Regional Evaluation of Street Sweeping As a Water Quality Control Measure," May 1980
- Technical Memorandum 39 - "Recreation and Open Space Benefits of Water Pollution Control Programs," May 1980
- Technical Memorandum 40 - "The Influence of Street Surface Type and Condition on Street Solids Loading Rate and Composition," September 1980
- Technical Memorandum 41 - "Requirements for Erosion and Sediment Control Plans," March 1981
- Technical Memorandum 43 - "Vegetation Methods for Construction Site Stabilization," January 2, 1981
- Technical Memorandum 44 - "Outline for Watershed Plan Final Reports," February 1980
- Technical Memorandum 45 - "Evaluation of Using Parking Restrictions To Increase Street Sweeping Effectiveness," February 1980
- Technical Memorandum 46 - "Financing Surface Runoff and Erosion Control Measures in Urban Areas," February 1980
- Technical Memorandum 47 - "Model Erosion and Sediment Control Ordinance," August 1980
- Technical Memorandum 48 - "Assessment of Construction Inspection and Inspector Training Programs for Erosion Control," March 1980
- Technical Memorandum 49 - "Catch Basin and Storm Sewer Cleaning As Surface Runoff Control Measures," March 1980
- Technical Memorandum 50 - "Enforcement Guidelines for Erosion Control Inpsectors," March 1980
- Technical Memorandum 51 - "Recommended Planting Time for Vegetative Stabilization of Construction Sites," August 1980
- Technical Memorandum 52 - "Model Parking Ordinance to Increase Street Sweeper Effectiveness," June 1980

- Technical Memorandum 53 - "Analysis of Watercourse Protection Ordinances," April 1980
- Technical Memorandum 54 - "Water Quality Problem Statement For Oil and Chemical Spills," September 1980
- Technical Memorandum 55 - "Erosion-Related Water Quality Problems," September 1980
- Technical Memorandum 56 - "Economic Assessment of Recreational Benefits From Water Pollution Control Programs," July 1980
- Technical Memorandum 57 - "Leaf Removal as a Surface Runoff Control Measure," April 1980
- Technical Memorandum 58 - "Litter Control as a Surface Runoff Control Measure," April 1980
- Technical Memorandum 59 - "Assessment of Erosion Control Costs To Local Governments and Private Sector," May 1980

Technical Memoranda Nos. 36 and 42 are not included because they were superseded by later technical memoranda.

WQMP ISSUE PAPERS

- Issue Paper No. 3, "Strategy for the 1979/80 Work Program," December 1978
- Issue Paper No. 4, "Strategy for 1980 Plan Update," September 1979
- Issue Paper No. 5, "Implementation of Surface Runoff Control Measures," December 1979
- Issue Paper No. 6, "Incentives for Implementation of Watershed Protection Plans," February 1980
- Issue Paper No. 7, "Selection of Design Storm for Erosion Control," June 1980

WATER QUALITY MANAGEMENT PLAN

GRADING ORDINANCES AND SURFACE RUNOFF CONTROL

Technical Memorandum No. 34

November 28, 1979

I. Problem Statement*

Erosion, sedimentation and stormwater runoff constitute a major water quality problem in the Bay Area. Eroded soil makes streams turbid, covers fish spawning beds, clogs streams and reduces reservoir capacity. Twenty-eight percent of the reservoirs in the Bay Area are identified as having sedimentation problems. The actual number affected is probably much greater. Most of the $5 million currently being spent on lake improvement is related to this problem.

The Regional Water Quality Control Board has estimated that approximately 10 million cubic yards of material are dredged annually from waterways in the Bay Area at a cost of about $12 million.

Much of this suspended solids load is caused by disturbance of the land surface. Table I presents information collected by the Environmental Protection Agency on increased erosion from various land uses.

The table shows that construction causes surface erosion to increase from 10-2,000 times the pre-construction condition. The amount of impact depends on the initial ground cover, slope, soil characteristics and rainfall.

*This section of the Memo is adapted from work done by Steven J. Goldman.

TABLE I

Surface Erosion Resulting From Land Disturbance

Initial Status	Disburbance	Magnitude of impact by the specific disturbance*
Forestland	Planting row crops	100-1,000
Grassland	Planting row crops	20-100
Forestland	Building logging roads	220
Forestland	Woodcutting	1.6
Forestland	Fire	7-1,500
Forestland	Mining	1,000
Row Crop	Construction	10
Pastureland	Construction	200
Forestland	Construction	2,000

The magnitude of sediment yields from construction sites is well documented (Leopold, 1968, Thronson, 1976). For very small areas, the volume of sediment from construction areas (both dwellings and roadways) may exceed 20,000 to 40,000 times the amount from farms and woodlands in an equivalent of time (Wolman and Shick, 1967). In larger drainage areas, construction may increase sediment yield from 10 to 2,000 times over previous levels (EPA, 1976). In an analysis of 48 Northern California reservoirs, 34 variables were studied for their effect on reservoir deposition. Of these many variables, secondary roads located near streams draining to the reservoir made the single greatest contribution of sediment (Anderson, 1976).

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*Relative magnitude of surface erosion from disturbed surface, assuming "1" for the initial status. The first row of the table, for example, indicates that transforming a forestland into row crops will increase surface erosion 100 to 1,000 times.

A local example of construction as a source of sediment to reservoirs is provided by East Bay Municipal Utility District (EBMUD). EBMUD, owner and operator of San Pablo Reservoir has determined that residential construction in the upper portion of the watershed is the major source of sediment to the reservoir. Largely as a result of the construction, an average of 170,000 cubic yards of sediment per year has entered the reservoir during the past decade (Hartman, 1977). Should it be deemed necessary, the cost of removing the sediment from the lake would be nearly $12 million (@ $7/cubic yard).

Another example where specific knowledge is available is in the Colma Creek Watershed (San Mateo County). During a peak construction period in this watershed a detailed study was performed by the U.S. Geological Survey. It was found that 72% of the sediment transported from the basin was derived from construction areas representing only 14% of the basin area (Knott, 1973).

Lake Temescal in Oakland was originally 65 feet deep when constructed. It is now filled with over 40 feet of sediment, largely resulting from freeway and residential construction on the slopes above it. Swimming in this regional recreation area has been curtailed because of the danger caused by the deep, quicksand-like deposits at the bottom. In Contra Costa County, Walnut Creek accumulates about 160,000 cubic yards of sediment each year in its lower reaches. The county annually allocates about $250,000 for dredging the creek.

Allowing development to proceed without adequate controls is costing local taxpayers millions of dollars each year. Much of this money is spent for dredging watercourses and for road maintenance. The long-term costs of loss of top soil and impairment of beneficial uses of water bodies are largely unquantified. These costs are undoubtedly far greater than the direct clean-up costs.

II. Grading Ordinances as One Method for Solving the Problem

Erosion, sedimentation and stormwater runoff related to construction activities are usually controlled by cities and counties in the Bay Area through administration and enforcement of local grading ordinances. These ordinances generally provide that for grading activities greater than some specified minimum, the developer or landowner must devise a grading plan, seek a grading permit, perform the operation in a relatively regulated way - and possibly even post a bond which the local government can use to correct violations if the work is not undertaken in a satisfactory manner.

ABAG has conducted a survey to determine the source of local grading ordinances in the Bay Area. The results are presented in Table II. As the table indicates, of the 92 jurisdictions within the region's water quality study boundary, 41 have adopted "Chapter 70 - Excavation and Grading" of the Uniform Building Code as local policy on the matter. Another 37 cities and counties (including 4 cities in Contra Costa County which use the County's ordinance) use their own locally developed

TABLE II

LOCAL GRADING ORDINANCES

JURISDICTION	CH. 70-UBC	OWN ORDINANCE	OTHER
Alameda County*		X	
Alameda (city)			No specific ordinance
Albany	X		
Berkeley	X		
Emeryville			No specific ordinance
Fremont		X	
Hayward		X	
Livermore	X		
Newark	X		
Oakland		X	
Piedmont	X		
Pleasanton	X		
San Leandro	X		
Union City	X		
Contra Costa County		X	
Antioch	X		
Brentwood			County's ordinance
Clayton			County's ordinance
Concord			Ch. 70 and local policies
El Cerrito	X		
Hercules		X	
Lafayette			County's ordinance
Martinez	X		
Moraga			County's ordinance
Pinole	X		
Pittsburg	X		
Pleasant Hill	X		
Richmond		X	
San Pablo	X		
Walnut Creek		X	
Marin County		X	
Belvedere	X		
Corte Madera		X	
Fairfax		X	
Larkspur	X		
Mill Valley			Ch. 70 and local policies
Novato		X	
Ross			Ch. 70 and local policies
San Anselmo	X		
San Rafael	X		
Sausalito	X		
Tiburon	X		

JURISDICTION	CH. 70-UBC	OWN ORDINANCE	OTHER
Napa County			Ch. 70 and local policies
Calistoga	X		
Napa (city)	X		
St. Helena	X		
Yountville	X		
San Francisco		X	
San Mateo County		X	
Atherton	X		
Belmont		X	
Brisbane		X	
Burlingame			Ch. 70 and local policies
Colma	X		
Daly City	X		
Foster City		X	
Half Moon Bay	X		
Hillsborough		X	
Menlo Park	X		
Millbrae			Ch. 70 and local policies
Pacifica			Ch. 70 and local policies
Portola Valley		X	
Redwood City			No specific ordinance
San Bruno		X	
San Carlos		X	
San Mateo (city)		X	
South San Francisco		X	
Woodside		X	
Santa Clara County		X	
Campbell			No specific ordinance
Cupertino		X	
Gilroy	X		
Los Altos			No specific ordinance
Los Altos Hills		X	
Los Gatos	X		
Milpitas	X		
Monte Sereno		X	
Morgan Hill	X		
Mountain View			No specific ordinance
Palo Alto		X	
San Jose		X	
Santa Clara (city)	X		
Saratoga		X	
Sunnyvale	X		
Solano County*	X		
Benicia	X		
Fairfield*			Ch. 70 and local policies
Suisun City*		X	
Vallejo		X	
Sonoma County	X		
Petaluma	X		
Sonoma (city)	X		

*New ordinance under development

ordinances exclusively. Eight jurisdictions employ a combination of Chapter 70 and local policies. Finally, six jurisdictions use neither Chapter 70 nor any formal local policy, although in some cases informal administrative procedures are used to impose grading, erosion and/or stormwater runoff control requirements in the absence of a statute.

ABAG has also analyzed the technical features of a select number of grading ordinances now in operation (or under consideration, as in the case of Solano County and two of its cities) in the Bay Area. The results from this analysis are presented in Table III.

Whether a city or county uses Chapter 70 or its own ordinance to control grading activities, it is expressing local policy on the matter. Interestingly, if a jurisdiction uses its own ordinance, this does not automatically mean that it is controlling erosion, sedimentation and stormwater runoff any better than a city or county which uses Chapter 70. For example, at the Villa Mira Vista development in Richmond, uncontrolled siltation of Wildcat Creek and the resulting impairment of its beneficial uses has cast light on Richmond's grading ordinance used to control such problems; the Regional Board has even requested that Richmond revise its ordinance so that future construction activities do not create this kind of pollution.

The presence of siltation problems in areas such as Lake Temescal, Colma Creek, Wildcat Creek and other Bay Area watercourses indicates that local governments in the region are not controlling erosion, sedimentation and stormwater runoff as well as they might. Specifically, Chapter 70 of the Uniform Building Code and the collection of local grading ordinances used in the Bay Area could be improved in a number of ways.

For example, none of the ordinances - including Chapter 70 - states expressly that water quality protection is one of its intended purposes. Of the 92 cities and counties in the 208 study area, only 5 existing ordinances (those in Monte Sereno, Portola Valley, Saratoga, Vallejo, and Walnut Creek) state any relationship at all between the ordinance and watercourse protection, and a reading of these ordinances shows that their apparent purpose is to prevent flooding, not water quality degradation.

Another major failing of local ordinances is their lack of sufficient guidance on erosion, sedimentation and stormwater controls. No existing ordinance calls for the use of Best Management Practices, such as are found in the "Erosion and Sediment Control Handbook," published by the California Department of Conservation in May 1978. Most ordinances give local officials unguided discretion in determining the standards and practices necessary for compliance. One prominent exception to this is the draft now being considered by Solano County and two of its cities; this proposed ordinance indicates that controls may be incorporated from the County's "Erosion and Sediment Control Handbook," which lists Best Management Practices for this purpose.

TABLE III:
COMPARISON OF SELECTED BAY AREA GRADING ORDINANCES

	Chap 70 1976 UBC	Hayward	Oakland	Contra Costa County, Brentwood, Clayton, Lafayette, Moraga	Concord	Hercules	Richmond	Walnut Creek	Marin County	Novato	San Francisco	Santa Clara County	San Jose	Solano County (draft)
Ordinance inapplicable when:														
Cut														
Quantity, cu yd		<300	<50	<200		<200	<200					<150		<500
Depth, ft	<2	<4	<5	<5	<2	<5	<5	<3		<2		<5	<2	<5
Slope, H: V	<1½:1		<20%	<2:1	<1½:1	<2:1	<1½:1	<2:1	<2:1	<5:1			<2:1	<2:1
Height, ft	<5	<5	<5	<7	<5	<7		<5	<8	<5		<5	<5	
Fill														
Quantity, cu yd	<50	<300	<50	<200	<50	<200	<200	<50	<500	<100		<150	<50	<500
Depth, ft	<3	<4	<5	<3	<3	<3	<3	<1	<3	<3		<5	<3	<5
Slope, H: V	<5:1		<20%	<5:1	<5:1	<5:1	<5:1	<5:1	<5:1	<5:1			<15%	<10:1
Grading in isolated areas	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Building official may require:														
Soils engineer report	✓	✓		✓	✓	✓	✓	✓	✓	✓		✓	✓	✓
Engineering geologist report	✓	✓		✓	✓	✓	✓	✓	✓			✓	✓	
Bond required	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓
Cut														
Maximum slope, H: V	2:1	2:1		2:1	2:1	2:1	1½:1	2:1		1½:1	1½:1	1½:1	2:1	2:1
Maximum height, ft		<40		<40		<40				<20	10	<30		
Fill														
Maximum slope, H: V	2:1	2:1		2:1	2:1	2:1	2:1	2:1		2:1	2:1	2:1	2:1	
Maximum height, ft.		<30		<30		>30				<20		<30		
Bench if depth, ft	>5	>5		>5	>5	>30 or >5:1		>5:1		>30	>5:1	>5:1		
Runoff diversion														
Required if upslope path, ft	>40			>30	>40					>30				
Protected discharge required	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	
Erosion control														
Slope stabilization	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓
Slope stabilization specified		✓				✓	✓	✓		✓		✓	✓	
Slope stabilization bonded till established				✓		✓	✓			✓		✓		
Other devices required	✓	✓			✓	✓		✓		✓		✓	✓	✓
Omit if erosion resistant	✓				✓	✓				✓	✓			✓
Special conditions during wet weather (Oct-Apr)		✓		✓		✓	✓	✓		✓				

Problems exist in ordinance administration and enforcement. Plan checkers generally are not sufficiently familiar with water quality aspects of erosion, sedimentation and stormwater control, and there is no review of permit applications by Regional Board staff or others who are. Waivers and exemptions from grading permits, bonds and other requirements are often freely available. Filing fees are insufficient to cover the cost of adequate site inspection. Inspections themselves may be conducted in a haphazard manner.

These problems are mentioned not as a complete list, but to be illustrative. In short, Chapter 70 and other local grading ordinances fare rather poorly in establishing the legal bottom line for regulating these activities.

ABAG staff has reviewed all grading ordinances now in use in the Bay Area. Staff has also analyzed ordinances used outside the region and a number of so-called "models." Based on this review, staff has developed a list of grading ordinance "features" which should be considered by local governments in the Bay Area wishing to improve the effectiveness of a local grading policy. The list, Table IV of this Memo, does not represent an exhaustive accounting of all the concepts which should be conveyed by a grading ordinance; nor is it presented in ordinance language. Rather, it lists ideas which, if administered and enforced, would effectively counter the problems of erosion, sedimentation and stormwater runoff and their relationship to water quality.

III. Conclusion

ABAG staff does not expect that every city and county in the Bay Area will embrace all the concepts presented in Table IV. However, it is also clear that improvements can and should be made, and that water quality depends in part on such changes. ABAG staff will work closely with city and county agencies to review local grading ordinances and develop workable changes that can be recommended to County Boards of Supervisors and City Councils for adoption.

More specifically, ABAG staff would like to see local government grading ordinances in the Bay Area brought up to a minimum level of quality and performance. This baseline level would be established through city and county enactment of a given, basic subset of the features in Table IV. Staff will discuss the Table IV list with agency personnel throughout the region so that this subset of features can be determined. Of course, any city or county wishing to adopt more than the basic grading ordinance would be free to do so as a matter of local policy. Features of a minimum level grading ordinance will be the subject of a subsequent Technical Memorandum.

TABLE IV. FEATURES OF AN EFFECTIVE GRADING ORDINANCE

General Provisions

1. Water quality protection, as well as protection against both on-site and off-site damage (i.e., erosion and sedimentation both) are expressed intents of the ordinance.

2. The ordinance contains a general prohibition on causing erosion or sedimentation. Section 19-16 of Montgomery County, Maryland's sediment control law, for example, provides that "No person shall engage in any land disturbing activity or by any action cause or permit any soil, earth, sand, gravel, rock, stone, or other material, or liquid to be deposited upon or to roll, flow, or wash upon or over the premises of another in a manner to cause damage to such premises without the express consent of the owner of such premises affected; no person shall engage in any land disturbing activity or by any action cause or permit any soil, earth, sand, gravel, rock, stone, or other material or liquid to be deposited or to roll, flow, or wash upon or over any public street, street improvement, road, sewer, storm drain, watercourse, or right-of-way, or any public property in a manner to damage or to interfere with the use of such property...". This particular ordinance goes on to provide for notification of violators, remedies for correction, penalties, and payment procedures for removing the material.

3. The ordinance provides for a public education/information program, technical assistance by the administering agency, seminars or workshops for developers, engineers, inspectors, and so on to increase the public awareness for and acceptance of the program.

4. Policy guidance in the ordinance is specific, and staff discretion to grant waivers and exemptions is limited to situations only where authorized.

Ordinance Administration and Grading Permits

1. The application procedures for grading and building permits are coordinated.

2. Administration of grading procedures is coordinated with Environmental Impact Report/environmental assessment/project review procedures. Where a grading permit is required, an environmental assessment form is completed to determine if an Environmental Impact Report must be prepared. Project review guidelines take grading activities into account.

3. A maximum time period between the filing of application materials and issuance of a grading permit is specified in the ordinance.

4. A soil and/or geological report is provided as part of the grading permit application where required by the ordinance.

5. A grading permit is required where erosion, sedimentation and/or stormwater runoff are likely to affect water quality.

6. All exempt and minor grading activities for which a permit is not required or discretionary are specified in the ordinance.

7. Permit exemptions are not available for grading in isolated areas or for grading of a minimum acreage; an exemption may be available for a minimum quantity of fill or excavation material - 50 cubic yards or less, for example.

8. When a grading permit is required by the ordinance, it is conditioned on approval of a grading and erosion control plan.

9. A grading plan contains an erosion control plan. The erosion control plan specifies the control measures to be used to prevent erosion and sedimentation, the schedule for implementing these controls and identification of spoil disposal procedures. The erosion control plan also contains the calculation methods used to size the control measures, the design specifications for these measures (including maps and sketches) and an estimate of time of exposure of graded areas prior to implementation of the erosion controls.

10. The grading and erosion control plan is reviewed and signed by a registered professional engineer.

11. The ordinance contains procedures for modification of the grading and erosion control plan where it is found inadequate by the permittee or inspector.

12. Grading permit applications, including the grading and erosion control plan, are reviewed in specified instances by the Regional Water Quality Control Board, the Council of Bay Area Resource Conservation Districts or the local Resource Conservation District.

13. The ordinance places a time limit of one year on the grading permit, with extensions on a case-by-case basis.

14. For minor grading operations where a permit is discretionary but based on identified considerations, information on the land disturbance is filed nonetheless with the administering agency before commencement of work.

15. Grading permit/filing fees are gauged on full cost recovery of all processing, plan checking, inspection and other expenses of the administering agency.

16. The ordinance provides for a specialized staff trained in the control of erosion, sedimentation and/or stormwater runoff.

17. The number and timing of on-site inspections is specified in the ordinance.

18. Inspection results are reported directly in writing to the permittee.

19. A copy of the grading and erosion control plan is maintained on the work site and is available to the inspector at all times.

20. The permittee notifies the administering agency 48 hours before any land disturbance is undertaken and after the final grading and land stabilization is performed.

21. The permittee secures approval from the administering agency before removing any erosion, sedimentation or stormwater control structure.

22. The permittee files a certificate of project completion with the administering agency, which then conducts the final inspection and prepares a written final report for its files, with a copy to the permittee.

Level of Protection

1. All erosion, sedimentation and/or stormwater runoff controls are to be based on Best Management Practices and provided before, during and after construction.

2. The ordinance refers to a specific locally approved Best Management Practices handbook (the "Erosion and Sediment Control Handbook," published in May 1978 by the California Department of Conservation, for example) as a set of guidelines instead of attempting to describe them in the ordinance itself.

3. Public works agencies, although exempt from grading permit and bond requirements, are not exempt from application of Best Management Practices, the need to file a grading and erosion control plan, the inspection requirements, and so on.

4. Special protection is required for sensitive habitats and steep slopes, and on highly erodible soil.

5. The ordinance requires that specific protective measures be in place by September 1 (for example) so that they can be inspected before the rainy season begins; grading activities take place only under specified circumstances from October 15 to April 15.

6. The ordinance limits the amount of land that can be disturbed at any one time.

7. Existing vegetation is removed only where necessary.

8. The ordinance has a specific provision for protection of adjacent property.

9. All disturbed soil surfaces are stabilized and revegetated in a given time.

10. The ordinance calls for mitigation of dust, noise, and other adverse effects of grading.

11. Water quality considerations are taken into account during spoil disposal.

12. The timing and location of spoil disposal is specified.

13. The ordinance provides that access roads and haul routes minimize potential erosion, sedimentation and stormwater runoff problems.

14. The ordinance requires that home buyers and other landowners be provided with maintenance instructions on how to minimize erosion and sedimentation after construction.

<u>Enforcement</u>

1. Where a grading permit is issued, a surety bond, cash bond or irrevocable letter of credit is required, and procedures for its use are set out in the ordinance; one suggested level is 100% of the cost of the grading work.

2. Waivers and exemptions from the bond/letter of credit requirements are given only under specific conditions listed in the ordinance.

3. Bonds or letter of credit funds are used by the administering agency to correct actual and potential erosion, sedimentation and/or stormwater runoff problems, and to make repairs.

4. The administering agency has a right of entry to prevent erosion, sedimentation and/or stormwater runoff, and for repairs.

5. If bond or letter of credit funds are not adequate to correct any problems, the ordinance provides for liens against the property where public funds are spent.

6. The bond or letter of credit funds are not released for a given period of time until erosion, sedimentation and/or stormwater controls are proven adequate.

7. Penalties include temporary suspension of the grading permit, revocation of the grading permit (perhaps after a public hearing, with temporary suspension until the hearing), use of bond/letter of credit funds, use of public funds if necessary with a lien on the property, stop work/cease and desist orders, fines and other criminal sanctions, and so on.

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WQ/Tech #35
Yucel

WATER QUALITY MANAGEMENT PLAN

STREET SURFACE POLLUTANT ACCUMULATION AND REMOVAL

Technical Memorandum No. 35
October 1979
Revised September 1980

INTRODUCTION

This technical memorandum summarizes literature findings related to the nature, accumulation and removal of pollutants from street surfaces. Data were obtained from studies conducted nationwide and locally over the last decade. The findings from this literature review provide direction for development of programs to improve the effectiveness of existing public works practices. A future technical memorandum will analyze the cost effectiveness of proposed programs.

The Environmental Management Plan for the San Francisco Bay Area recommends improved street sweeping as a cost-effective and preventive type of surface runoff pollution control measure. Street sweeping has held a traditional place in the urban environment. The public works departments of local jurisdictions consider street sweeping a major element of their street cleaning programs with objectives of maintaining aesthetics, health, and public safety.

If adequately designed, street cleaning programs can reduce some of the pollutants affecting the receiving water quality. Particulates which accumulate on street surfaces and are blown by the wind also have air quality impacts. Therefore, improvement of the existing street cleaning programs with the additional objectives of water and air quality could provide for a cleaner urban environment.

The impact of the existing street sweeping programs in the Bay Area on surface runoff quality has not been determined. ABAG proposed to conduct, as part of the 208 continuing planning program for the Bay Area, a regional evaluation of street sweeping as well as other urban surface runoff control measures. This memorandum forms part of that evaluation.

NATURE OF POLLUTANTS ON STREET SURFACES

Local soil erosion and motor vehicle emissions and wear contribute most of the pollutants residing on street surfaces. Roadway abrasion is a small contributor, yet significant amounts may result from poor

surface conditions. Spills, leaks and litter from traffic and human activities deposit variable amounts and types of pollutants onto street surfaces.

Local plants and soils contribute most of the nitrogen and phosphorus. Pesticides, herbicides and fertilizers are applied on surrounding areas and are carried onto street surfaces by wind, rain and traffic. Heavy metals are due to mainly wear and emissions from motor vehicles. Grease, petroleum, and n-paraffin result from vehicle lubricants, antifreeze, and hydraulic fluids. Spills of oil additives contribute phosphorus and zinc; spills or combustion of leaded fuels deposit lead; asbestos and zinc are deposited from wear of tires, clutch and brake linings; copper, nickel and chromium are deposited from wear of platings and bearings.

A chemical analysis of typical street surface materials is presented in Table 1.

Relationship with Particle Size

Pollutants and their concentrations are characteristically associated with solids on street surfaces. The types of pollutants associated with solids of different particle size ranges is quite variable. In a recent study in San Jose (Pitt, 1979), each collected street sample was divided into eight particle sizes ($<45\mu$; 45-106 μ, 106-250 μ; 250-600 μ; 600-850 μ; 850-2000 μ; 2000-6370 μ; and $>6370\mu$). Chemical analyses were then carried out for each particle size. Findings indicate that mercury, cadmium, zinc, lead, Kjeldahl nitrogen, and total orthophosphates show higher concentrations with smaller particle sizes, while copper and chromium show the lowest concentrations with the smallest particle size. Large variations were observed for asbestos, yet the smallest particle sizes had the shortest observed maximum fiber lengths. Figure 1 presents the concentrations as a function of particle size for various pollutants for San Jose test areas. Figures 2 and 3 are derived from national data and present the percentage of various contaminants as related to particle size distributions.

Relationship with Land Use and Environmental Conditions

Nationwide averages of pollutant strengths from street surfaces associated with land use, climate, average daily traffic (ADT), road and surrounding conditions are presented in Table 2. Pollutant strengths are concentrations expressed as ppm, micrograms of pollutant per gram of total dry solids. The statistical analysis presents values for the mean ($\bar{x}$), standard deviation (σ), range (R) and number of samples (N).

The data were gathered from the comprehensive report "Water Quality Management Planning for Urban Runoff" (URS, 1974). URS reviewed nearly 150 publications of which only 13 contained sufficient data to provide the 153 data points which make up this data base. Four studies contributed most of the data: Tulsa Study (AVCO, 1970); Chicago Study

Table 1: Analysis of Typical Street Surface Contaminants

Material	Tot. Vol. Solids (mg/g)	BOD[a] (mg/g)	COD (mg/g)	Grease (mg/g)	Petroleum (mg/g)	n-Paraffins (mg/g)
Gasoline	1000	150	680	1.3	1.3	1.3
Lubricating Grease	970	140	-	750	670	570
Motor Oil	1000	140	220	990	940	850
Transmission Fluid	1000	100	200	990	940	880
Antifreeze	990	38	1100	140	70	6.1
Undercoating	1000	90	310	960	180	120
Asphalt Pavement	64	1.2	86	21	15	9
Concrete	71	1.4	64	2.7	1.3	1
Rubber	990	27	2000	190	100	56
Diesel Fuel	1000	80	400	390	310	210
Brake Linings	290	17	420	31	8.3	7.6
Brake Fluid	1000	26	2400	880	33	19
Cigarettes	860	85	780	30	21	2.7
Salt[b]	75	-	-	0	0	0
Cinders	0.0	-	59	1.3	1.2	1.2
Area Soil[c]	-	-	-	-	-	-

Material	Lead (µg/g)	Mercury (µg/g)	Chromium (µg/g)	Copper (µg/g)	Nickel (µg/g)	Zinc (µg/g)
Gasoline	660	<0.05	15	4	10	10
Lubricating Grease	<2	<0.05	<2	<1	<1	160
Motor Oil	9	<0.05	<2	3	17	1100
Transmission Fluid	8	<0.05	<2	<1	21	240
Antifreeze	6	<0.05	<2	76	16	14
Undercoating	120	<0.05	<2	1	480	110
Asphalt Pavement	100	<0.05	360	50	1200	160
Concrete	450	<0.05	93	99	260	420
Rubber	1100	<0.05	180	250	170	620
Diesel Fuel	12	<0.05	15	8	8	12
Brake Linings	1100	<0.05	2200	31,000	7500	120
Brake Fluid	7	<0.05	19	5	31	15
Cigarettes	490	<0.05	71	720	190	560
Salt	2	<0.05	2	2	9	1
Cinders	<2	<0.05	<2	3	4	7
Area Soil	<2	<0.05	36	23	25	27
Detection Limit	2	0.05	2	1	1	0.01

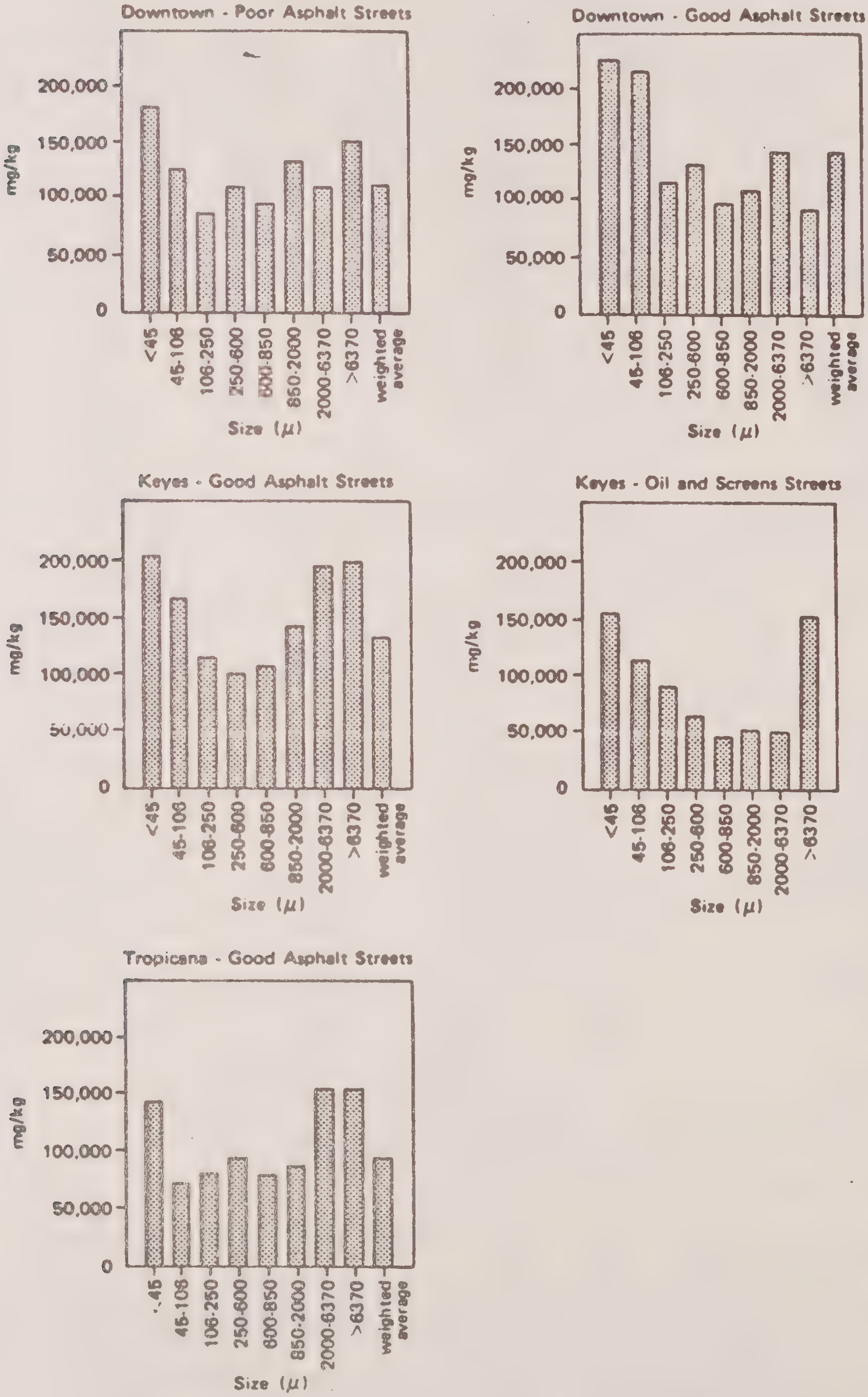
Source: Shaheen 1975

[a]BOD determinations were made on "pure" materials using a seed of unacclimated sewage organisms.

[b]Results are on a dry weight basis. Salt as received contained 3.7% water, assayed 93.2% sodium chloride, and contained less than 0.005% cyanide.

[c]Soils from the Washington, D.C. area contained a magnetic fraction of from 8.9% to 12.5%, less than 0.05 mg rubber per gram, less than 3 x 10^5 asbestos fibers per gram, 50 to 100 mg/g volatile solids and 15 to 80 mg/g COD.

Figure 1: Concentration as a Function of Particle Size

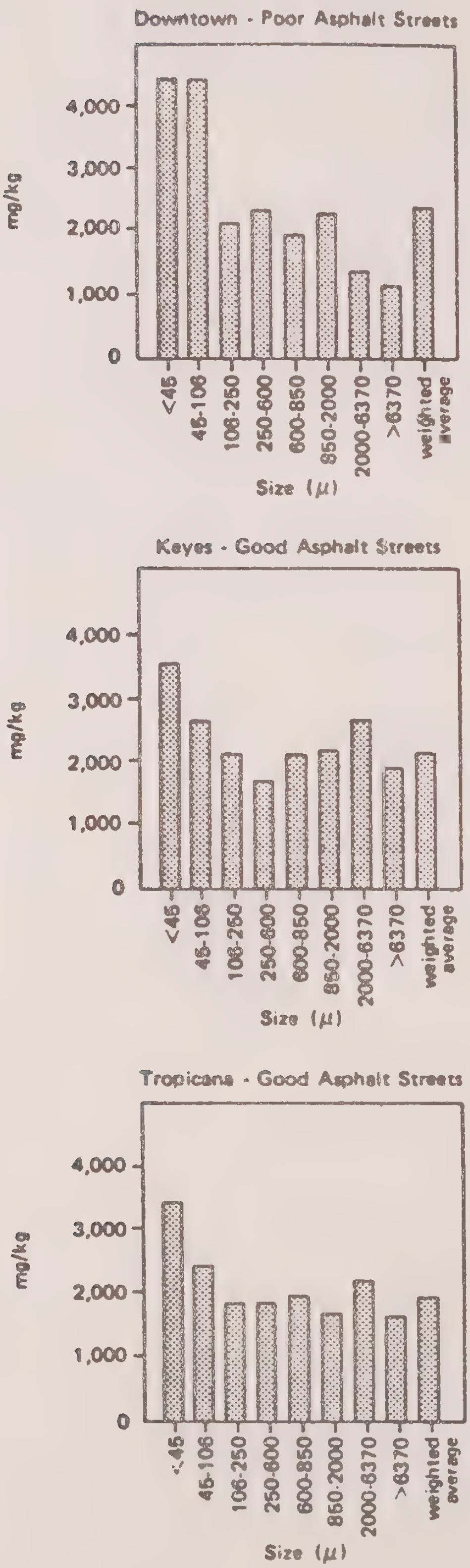


COD Concentrations as a function of particle size
(mg COD / kg total solids) - 12 / 13 / 76 through 5 / 15 / 77 average.

Figure 1 (continued)

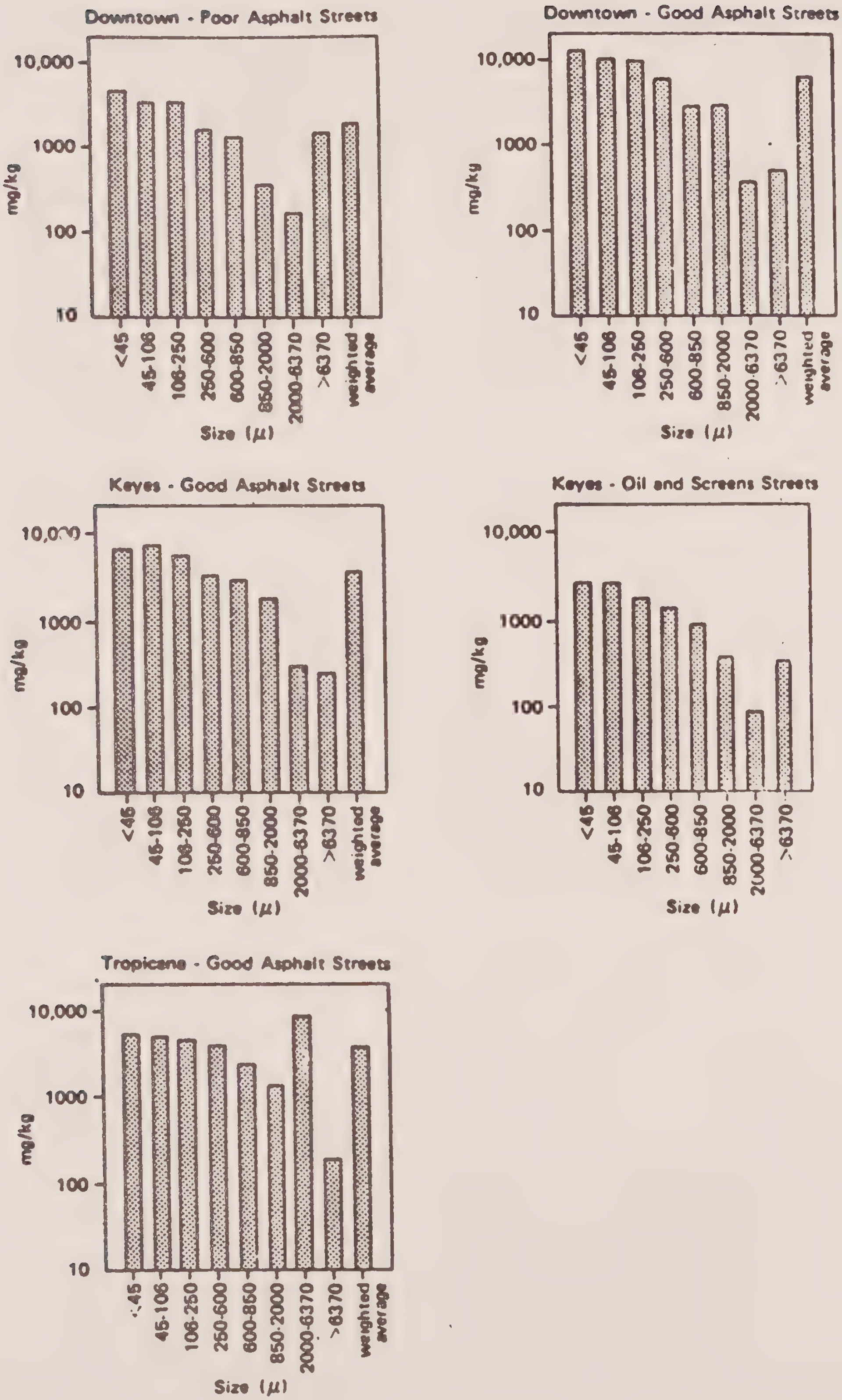
Total orthophosphate concentrations as a function of particle size (mg OPO_4/kg total solids) - 12/13/76 through 5/15/77 average.

Figure 1 (continued)



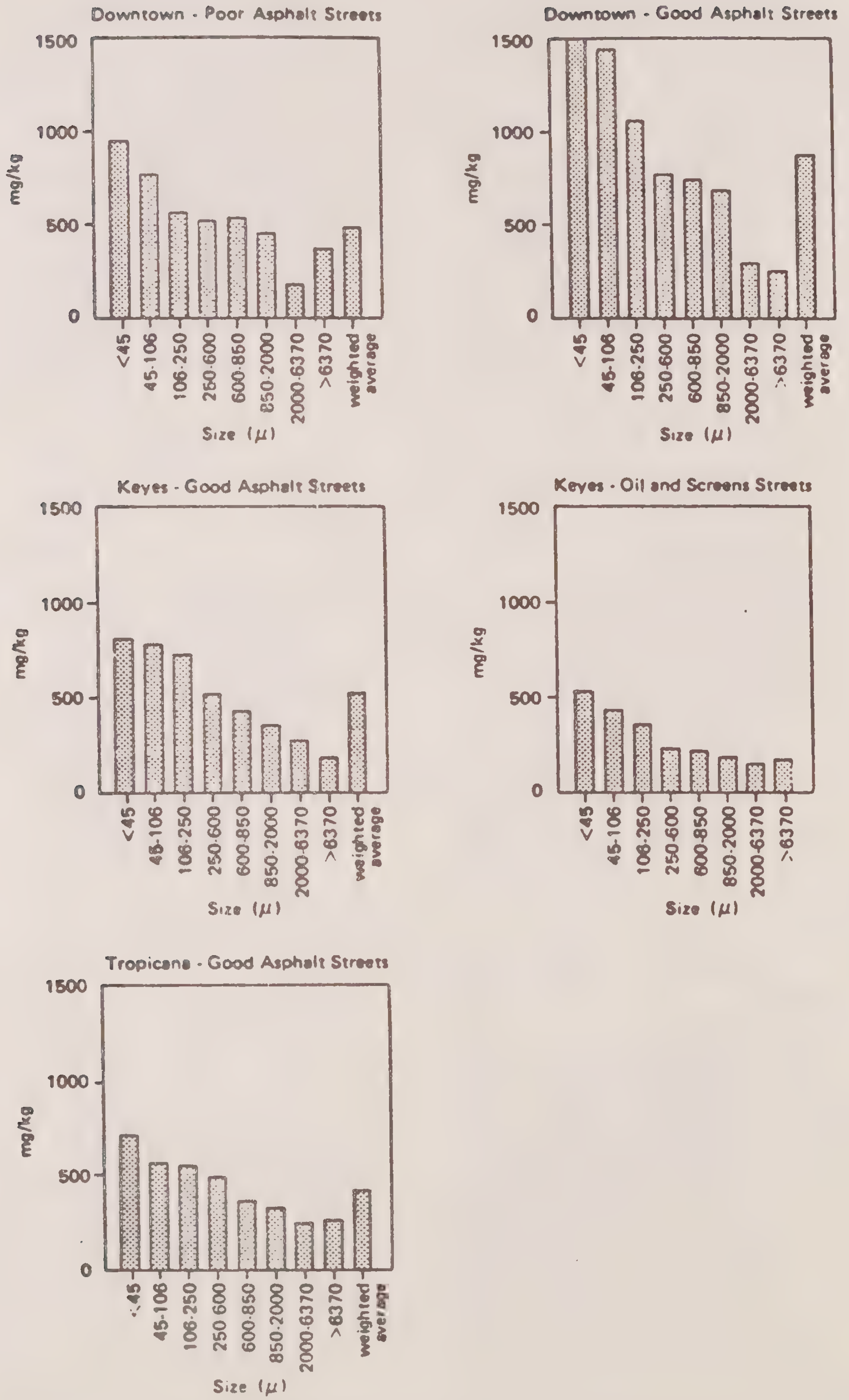
Kjeldahl nitrogen concentrations as a function of particle size (mg KN / kg total solids) - 12 / 13 / 76 through 5 / 15 / 77 average.

Figure 1 (continued)



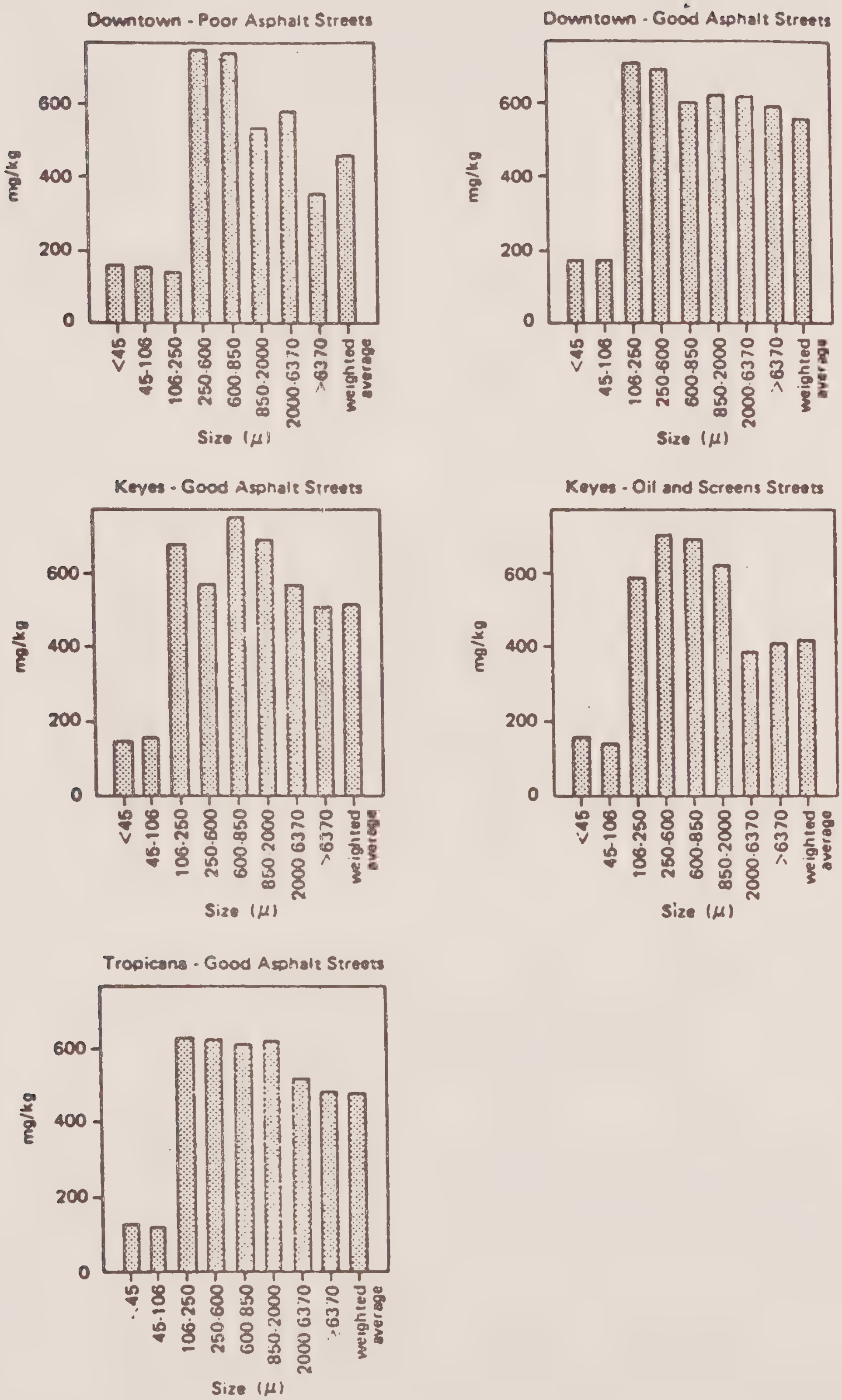
Lead concentrations as a function of particle size
(mg Pb/kg total solids) - 12/13/76 through 5/15/77 average.

Figure 1 (continued)



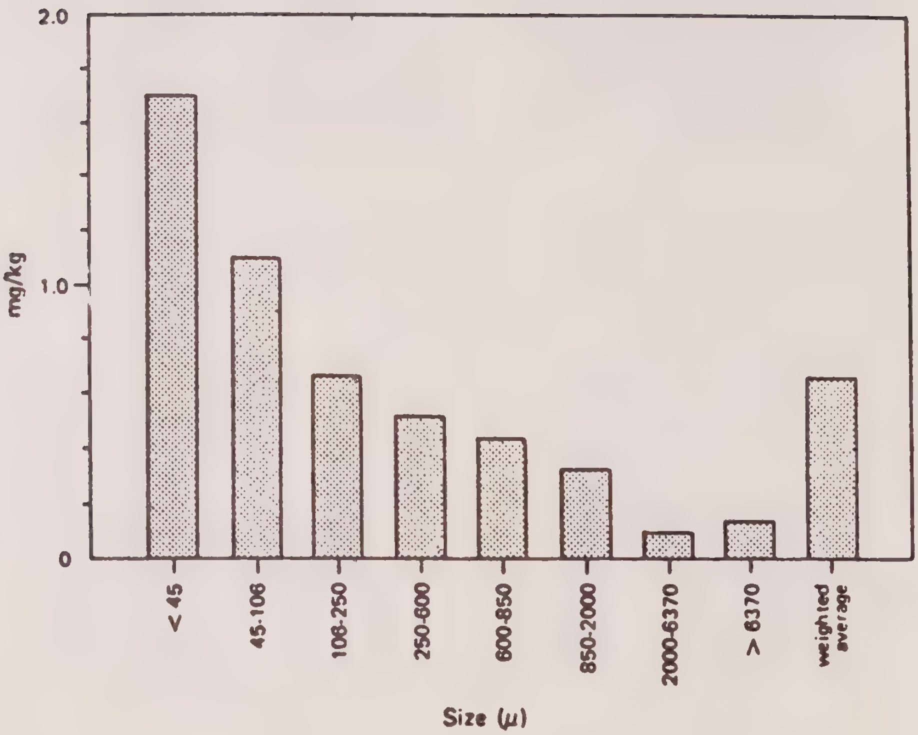
Zinc concentrations as a function of particle size
(mg Zn/kg total solids) - 12/13/76 through 5/15/77 average.

Figure 1 (continued)



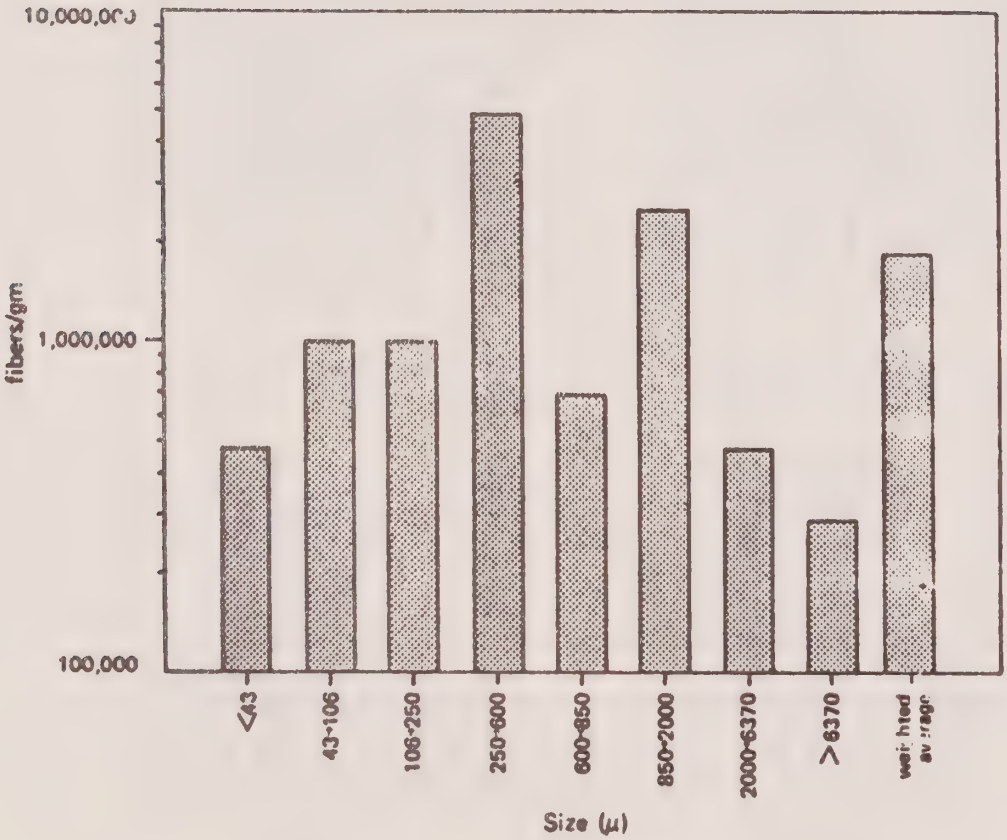
Chromium concentrations as a function of particle size
(mg Cr/kg total solids) - 12/13/76 through 5/15/77 average.

Figure 1 (continued)



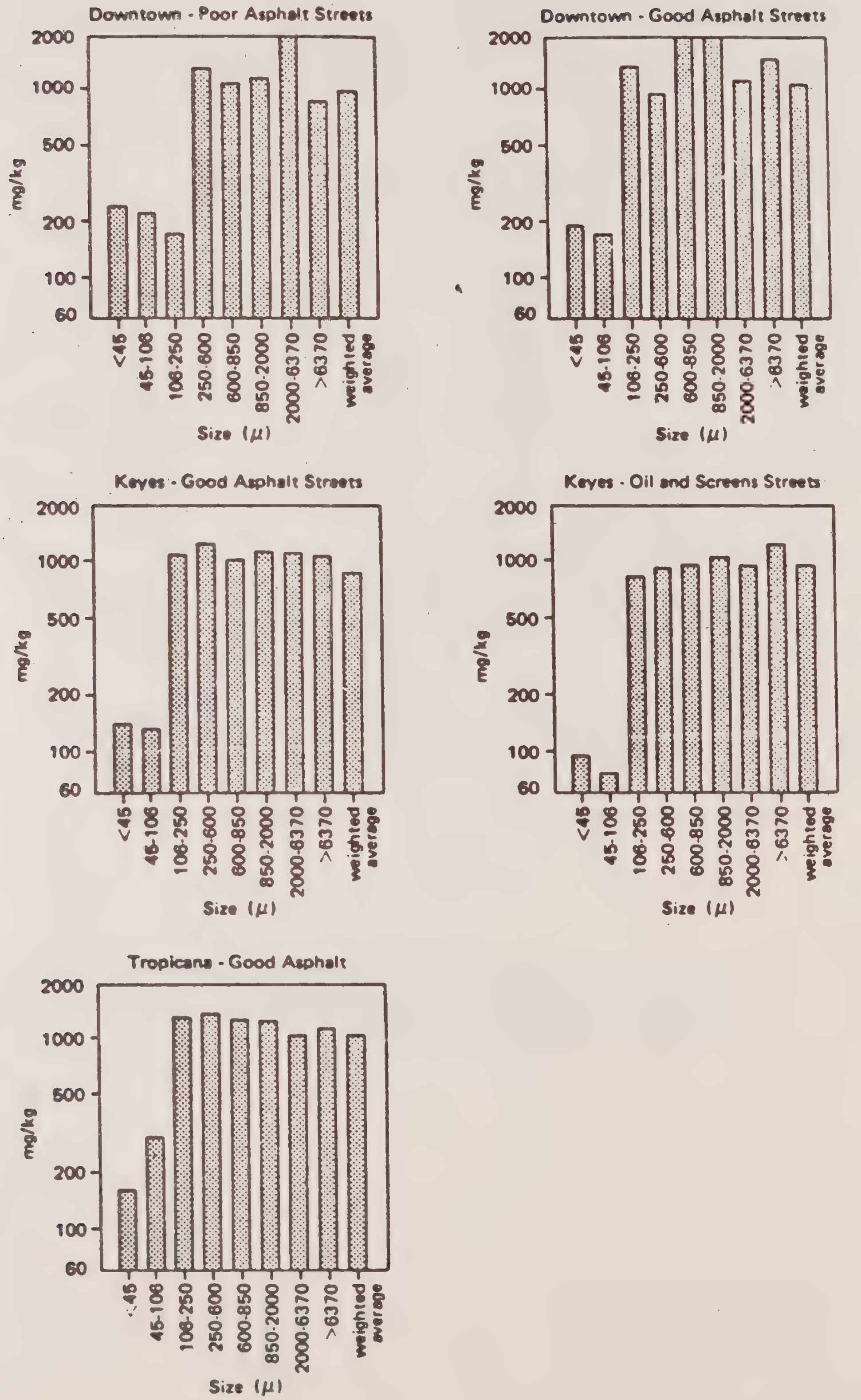
Mercury concentrations as a function of particle size - all test areas combined - (mg Hg/kg total solids) - 12/13/76 through 5/15/77 average.

Figure 1 (continued)



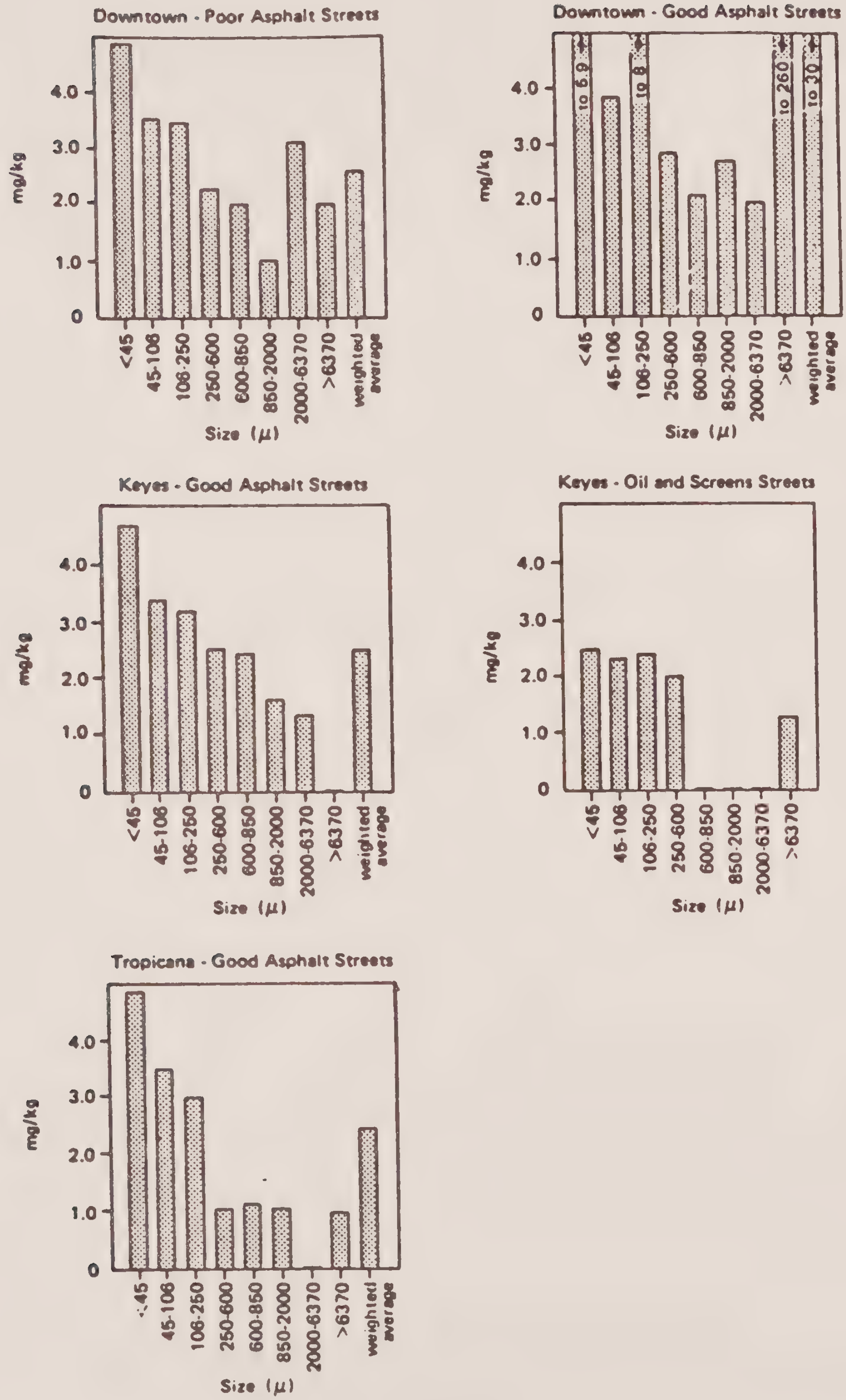
Asbestos concentrations as a function of particle size - all test areas combined - (fibers/gram total solids) - 12/13/76 through 5/15/77 average.

Figure 1 (continued)



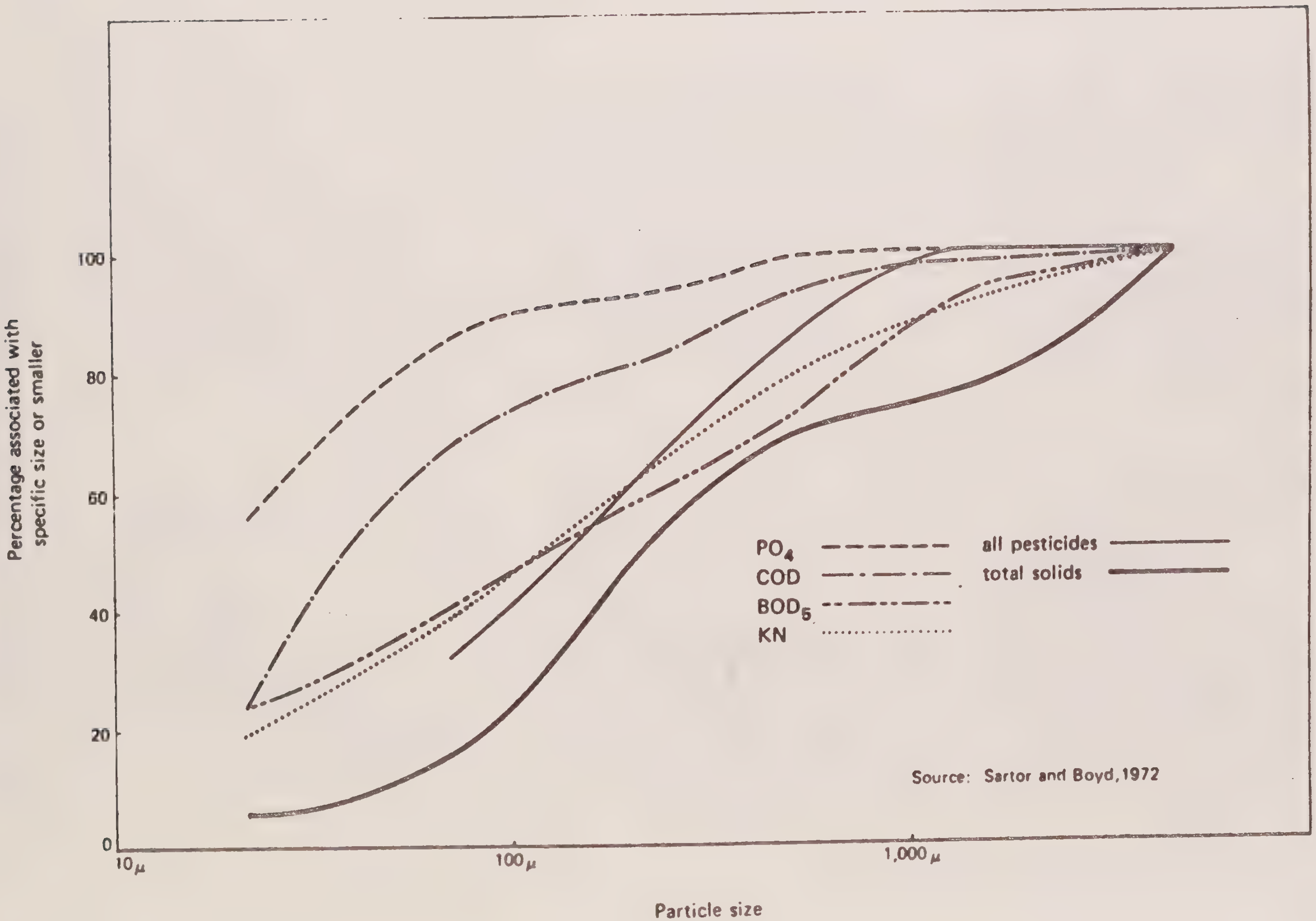
Copper concentrations as a function of particle size
(mg Cu/kg total solids) - 12/13/76 through 5/15/77 average.

Figure 1 (continued)



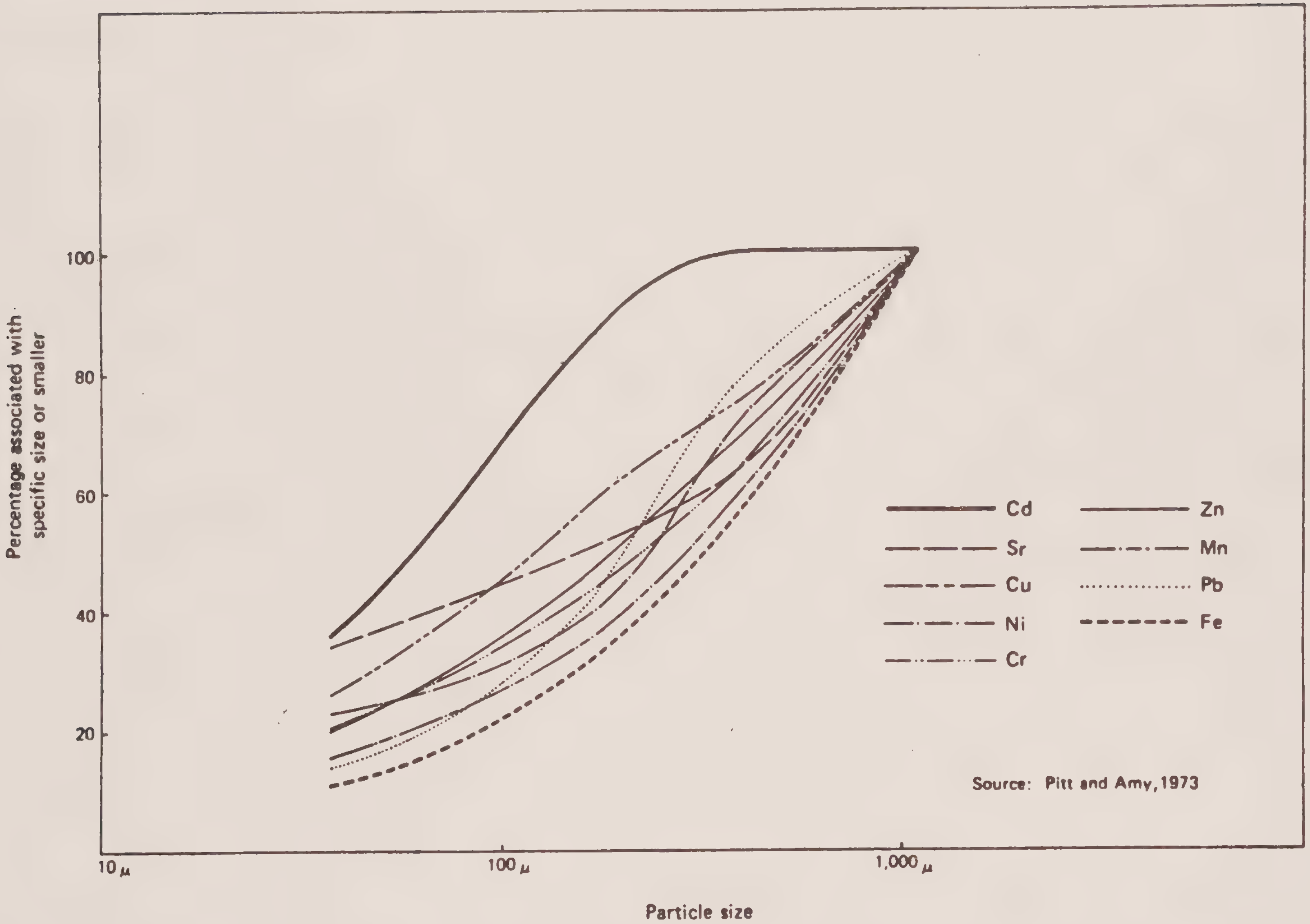
Cadmium concentrations as a function of particle size
(mg Cd/kg total solids) - 12/13/76 through 5/15/77 average.

Figure 2: Particle (<¼inch) Size Distribution for Some Contaminants



Source: Pitt, 1976

Figure 3: Particle (¼inch) Size Distribution for Various Heavy Metals



Source: Pitt, 1976

Table 2: Pollutant Strengths - Nationwide Averages Based on Land Use, Climate, and Road Conditions

			lbs/curb mi/day	Concentrations in Micrograms per Gram of Dry Solids																No./gram	
Category	#		Loading	BOD_5	COD	OPO_4	TPO_4	NO_3	NH_4	OrgN	Cd	Cr	Cu	Fe	Pb	Mn	Ni	Sr	Zn	TColi[b]	FColi[b]
LAND USE																					
Open land	10	X̄	12	20,300	171,000	1,700	5,440	16,000	-	7,250	0.4	5	9	2,600	15	-	6	-	22	1.6E5	7.1E5
		σ	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		R	-	18,200-22,300	91,000-252,000	-	-	-	-	1,700-12,800	-	-	-	-	-	-	-	-	-	.8 - 2.3E5	6.3 - 8.0E3
		N	1	2	2	1	1	1		2	1	1	1	1	1		1		1	2	2
Residential	20	X̄	149	14,000	82,000	850	2,000	550	660	1,800	3.0	192	93	20,600	1,430	392	20	21	350	1.7E6	1.6E5
		σ	195	11,900	81,800	904	1,050	742	-	774	2.2	63	37	7,020	1,030	120	27	16	152	2.5E6	2.0E5
		R	8-770	2,100-43,900	18,300-298,000	21-3,000	212-2,770	37-3,600	395-730	365-3,100	0-8.0	75-325	34-160	2,200-48,000	66-3,900	100-700	0-100	4-70	130-760	4.0E4-9.6E6	2.0E2-1.2E6
		N	65	37	35	38	5	33	3	26	48	48	48	48	51	49	48	46	48	49	48
Comm.	30	X̄	74	38,700	269,000	2,250	4,850	1,580	3,620	6,430	4.2	225	133	23,300	3,440	397	48	18	520	1.0E6	1.9E5
		σ	97	38,000	220,000	2,270	-	1,250	1,340	3,710	2.1	90	85	11,400	1,620	130	30	9	230	3.4E6	2.0E5
		R	3-326	4,030-175,000	24,800-611,000	27-6,670		323-4,400	1,880-5,390	1,600-11,880	1.5-9.3	63-430	63-300	5,000-42,000	1,300-7,600	160-770	7-140	5-37	190-1,100	3.1E4-1.5E7	2.2E2-9.7E5
		N	25	16	16	15	1	14	6	11	17	19	17	19	17	19	17	17	19	19	20
Light Industry	40	X̄	389	27,300	180,000	1,275	-	630	-	1,750	4.0	206	128	22,800	2,780	890	41	27	340	2.1E6	1.5E5
		σ	617	-	-	-	-	-	-	-	3.2	187	61	5,300	2,010	140	41	20	183	3.4E6	2.7E5
		R	41-1,850	15,000-39,600	73,000-224,000	240-2,700	-	72-790	-	1,600-1,900	0.7-11.0	130-760	71-280	15,000-31,000	740-9,999	300-500	6-120	6-93	37-480	4.0E4-1.0E7	3.0E1-6.9E5
		N	9	2	4	4	-	3	-	2	10	9	9	9	9	9	10	8	10	8	8
Industry	50	X̄	203	12,100	88,000	1,250	-	246	-	1,420	3.9	278	107	28,600	1,160	570	37	23	317	8.2E5	1.0E5
		σ	232	12,400	94,100	920	-	201	-	530	2.6	110	57	16,700	835	370	30	18	184	1.3E6	3.2E5
		R	16-800	2,850-35,000	17,000-267,000	14-2,900	-	72-431	-	490-1,800	0.3-8.8	120-585	32-210	8,100-72,000	260-3,500	180-1,600	6-93	8-77	140-800	2.7E4-2.6E6	6.5E2-9.1E5
		N	17	7	7	7	-	4	-	5	14	14	15	13	14	15	14	14	15	11	11
CLIMATE																					
Northeast	1	X̄	291	29,100	159,000	999	3,390	1,010	2,640	5,970	2.6	139	99	17,700	870	363	21	27	360	1.0E6	4.4E5
		σ	353	46,300	205,000	1,900	1,390	1,000	1,820	4,770	1.6	77	67	10,200	718	112	12	16	137	1.4E6	6.1E5
		R	19-1,500	1,720-175,000	18,000-611,000	14-6,670	2,130-5,440	89-4,400	595-5,390	365-12,800	0.4-6.3	5-335	9-170	8,100-43,000	47-2,700	230-620	4-36	7-41	57-630	8.0E4-3.6E6	8.0E3-1.3E6
		N	33	32	28	30	6	30	9	13	18	19	18	18	16	15	17	15	18	26	21
Southeast	2	X̄	103	29,100	172,000	2,240	212	43	-	1,970	4.0	234	137	20,300	1,370	395	21	28	439	1.9E6	7.0E4
		σ	113	17,500	119,000	710	-	-	-	640	3.2	156	66	10,000	1,230	240	15	26	240	2.6E6	1.4E5
		R	12-419	4,500-67,300	20,000-310,000	1,000-3,300	-	37-55	-	1,100-3,600	0 - 9.3	63-585	30-290	8,100-53,000	117-5,700	100-1,100	1-55	3-93	160-1,000	8.4E4-9.4E6	2.7E2-5.2E5
		N	38	19	19	17	1	3	-	17	24	25	24	24	26	25	24	24	25	30	31
Southwest	4	X̄	50	11,700	139,000	470	-	1,160	-	2,400	3.8	241	78	22,600	2,520	446	37	15	357	5.7E6	5.2E5
		σ	58	3,620	92,800	243	-	1,190	-	580	2.1	77	33	7,600	1,620	104	31	5	147	1.1E7	1.0E6
		R	3-238	8,900-17,000	34,000-312,000	170-750	-	130-2,730	-	1,000-3,200	0.3-8.8	75-325	25-150	11,000-48,000	220-7,400	280-700	0-140	5-20	130-720	2.5E4-3.4E7	7.2E1-8.2E6
		N	31	4	10	9	-	9	-	4	31	32	33	32	31	33	32	32	33	31	21
Northwest	5	X̄	30	10,000	30,000	1,100	-	59	-	2,000	1.8	246	96	34,500	2,600	455	35	10	400	6.8E5	1.1E6
		σ	18	-	-	-	-	-	-	-	0.8	10	50	11,600	1,090	25	7	5	82	11.0E5	1.3E6
		R	12-39	-	-	-	-	-	-	-	1.1-3.6	233-266	40-210	23,000-59,000	1,100-4,700	430-490	20-40	0-16	390-660	6.4E4-3.1E6	1.5E5-3.6E6
		N	7	1	1	1	-	1	-	1	7	8	8	8	8	8	8	7	8	7	6

Table 2 (continued)

Category	#		Loading (lbs/curb mi/day)	BOD_5	COD	OPO_4	TPO_4	NO_3	NH_4	OrgN	Cd	Cr	Cu	Fe	Pb	Mn	Ni	Sr	Zn	TColi[b]	FColi[b]
				Concentrations in Micrograms per Gram of Dry Solids																No./gram	
ADT	<500	$\bar{X}$	280	21,600	153,000	1,500	3,440	8,335	-	3,470	2.8	198	89	21,700	1,210	384	26	19	252	1.3E6	6.9E4
		σ	343	-	-	-	-	-	-	-	2.0	76	37	9,390	1,100	130	23	15	100	2.0E6	1.6E5
		R	12-950	6,320-39,600	45,600-252,000	73-2,700	-	670-16,000	-	1,700-12,000	0-5.4	132-395	33-150	13,000-43,000	200-3,900	210-620	7-75	3-33	110-420	8.4E4-5.6E6	5.0E2-4.5E5
		N	12	4	4	3	1	2	-	3	8	9	9	9	9	9	8	8	9	8	8
	500-5K	$\bar{X}$	140	9,500	83,000	741	212	419	-	1,515	2.9	196	107	18,900	1,060	415	17	34	410	2.1E6	3.4E5
		σ	155	8,520	83,200	950	-	269	-	846	1.6	62	31	3,500	925	140	18	32	198	2.5E6	4.6E5
		R	20-600	1,720-25,300	18,300-277,000	20-2,800	-	64-845	-	890-2,200	1.1-6.1	130-320	67-170	14,000-23,000	66-3,500	150-700	0-55	3-110	100-760	1.0E5-9.6E6	3.5E2-1.3E6
		N	24	16	16	15	1	11	-	7	12	12	12	12	15	12	11	12	12	17	16
	5K-15K	$\bar{X}$	146	27,400	163,000	1,340	2,980	836	2,640	2,900	3.0	215	107	22,500	2,010	442	38	18	375	3.1E6	1.7E5
		σ	211	26,000	165,000	1,250	1,070	979	1,820	2,430	2.5	80	62	10,000	1,480	172	33	18	167	7.1E6	2.8E5
		R	5-946	2,900-10,400	18,000-526,000	30-5,050	2,130-4,850	37-3,600	395-5,390	490-9,250	0.0-9.3	9-435	9-300	2,600-59,000	47-5,700	160-1,100	0-140	4-63	37-700	2.3E4-3.4E7	6.7E1-9.1E5
		N	61	38	42	43	5	37	9	38	54	54	56	56	54	55	58	51	54	57	53
	>15K	$\bar{X}$	82	5,720	26,980	514	-	501	-	1,600	3.1	203	102	22,900	2,230	337	28	18	309	3.8E5	1.4E5
		σ	104	-	-	-	-	-	-	-	2.1	93	69	13,400	1,530	105	23	11	160	5.4E5	2.1E5
		R	3-326	1,940-8,600	21,000-321,000	27-1,000	-	323-600	-	0	0-6.8	24-345	25-250	1,400-53,000	470-5,100	100-500	0-83	5-38	150-720	1.0E4-2.0E6	1.7E2-5.2E5
		N	17	4	4	4	-	4	-	2	16	16	16	16	15	15	15	15	16	12	11
AREA BEYOND — Lawns or grass	1	$\bar{X}$	196	32,400	154,000	1,720	3,500	1,010	3,620	3,900	3.9	197	96	21,040	1,370	406	27	24	348	8.3E5	7.4E4
		σ	245	37,900	172,000	1,490	2,860	1,320	1,340	3,240	3.9	71	39	8,500	980	157	25	20	160	1.6E6	1.4E5
		R	0-950	2,100-16,700	18,300-526,000	100-5,790	212-5,440	37-3,600	1,880-5,390	890-11,900	0.0-8.8	63-345	33-190	8,100-53,000	117-3,900	150-1,100	0-96	3-93	110-800	4.0E4-9.4E6	3.0E1-5.3E5
		N	55	29	31	28	3	25	6	26	50	51	53	51	53	51	49	51	53	60	50
Trees	2	$\bar{X}$	37	23,000	141,500	1,140	-	540	-	1,800	-	-	-	-	-	-	-	-	-	1.1E7	3.5E5
		σ	20	21,500	108,000	1,120	-	186	-	580	-	-	-	-	-	-	-	-	-	6.4E6	4.9E5
		R	19-96	2,900-67,300	24,500-312,000	28-3,300	-	482-940	-	1,200-2,700	-	-	-	-	-	-	-	-	-	3.9E5-8.6E7	7.0E3-1.3E6
		N	11	10	12	12	-	7	-	3	-	-	-	-	-	-	-	-	-	13	12
Landscaped	3	$\bar{X}$	93	9,990	86,900	824	-	721	-	2,600	4.6	262	120	34,500	2,350	430	33	22	552	3.5E6	3.5E5
		σ	56	11,600	96,900	1,370	-	230	-	-	-	-	-	-	-	-	-	-	-	3.0E6	3.4E5
		R	4-153	2,030-24,300	24,600-277,000	20-3,200	-	354-961	-	1,600-3,600	1.6-8.8	210-264	40-210	19,000-59,000	1,700-3,000	290-500	7-65	0-33	410-660	3.1E5-9.6E6	7.0E3-1.0E6
		N	10	7	7	7	-	5	-	2	4	4	4	4	4	4	4	3	4	8	8
Paved or bare	4	$\bar{X}$	121	13,700	78,000	787	2,510	461	662	1,200	3.6	220	116	22,000	2,370	446	41	16	385	7.1E5	1.6E5
		σ	151	10,200	71,100	590	-	232	-	594	2.1	87	77	9,320	1,720	154	34	8	162	1.1E6	2.8E5
		R	4-800	2,180-35,000	21,000-224,000	30-1,800	2,130-2,770	72-790	395-730	365-1,800	0.4-8.0	9-430	16-300	2,600-42,000	17-5,700	250-870	4-120	0-37	57-720	1.0E4-6.0E6	7.2E1-9.7E5
		N	40	17	13	17	4	16	3	11	34	35	35	36	34	35	34	35	34	28	28

Table 2 (continued)

Category	#		lbs/curb mi/day Loading	BOD$_5$	COD	OPO$_4$	TPO$_4$	NO$_3$	NH$_4$	OrgN	Cd	Cr	Cu	Fe	Pb	Mn	Ni	Sr	Zn	TColi[b]	FColi[b]
				Concentrations in Micrograms per Gram of Dry Solids																No./grams	
STREET SURFACE TYPE Asphalt	1	$\bar{X}$	150	23,000	150,000	2,470	212	11,600	-	1,770	3.7	217	107	22,400	2,000	414	43	18	380	-	-
		σ	225	14,900	91,000	562	-	-	-	792	2.3	78	64	8,570	1,590	141	41	12	170	-	-
		R	4-950	5,300-43,900	49,000-298,000	1,600-3,000	-	-	-		0 - 8.8	71-430	25-300	11,000-48,000	117-7,600	210-830	1.0-170	3-78	110-880	-	-
		N	65	9	9	7	1	1	-	7	55	59	60	58	60	60	57	58	59	-	-
Concrete	2	$\bar{X}$	38	72,000	383,000	3,520	5,150	2,600	3,620	6,600	3.5	173	97	22,800	1,200	342	24	45	292	-	-
		σ	17	51,700	163,000	1,730	-	920	1,340	3,940	2.9	100	31	13,300	814	154	15	38	114	-	-
		R	16-69	19,000-175,000	116,000-611,000	1,600-6,670	4,850-5,440	1,810-4,400	1,880-5,390	1,900-12,800	0.6-9.3	24-305	64-150	8,100-53,000	230-2,500	100-520	1-55	6-110	160-480	-	-
		N	16	13	13	11	2	7	6	13	10	11	11	10	10	10	10	11	10	-	-
ALL DATA		$\bar{X}$	156	19,900	140,000	1,280	2,930	804	2,640	2,950	3.4	211	104	22,020	1,805	418	35	21	370	2.5E8	1.7E5
		σ	220	19,800	155,000	1,440	1,750	977	1,820	2,850	2.3	90	58	9,980	1,290	130	33	17	170	5.7E6	2.9E5
		R	4-950	2,100-78,900	18,000-611,000	14-6,670	212-5,440	45-3,600	595-5,390	450-10,500	0 - 9.3	5-585	9-300	2,200-59,000	47-5,700	160-830	0-140	0-78	57-880	1.8E4-3.4E7	6.7E1-1.2E6
		N	119	60	68	69	7	53	9	44	91	93	93	93	89	88	93	89	91	95	88

a - Blanks indicate that no data were available.

b - Coliform counts are expressed in computer notation, i.e., E6 = 10^6.

Source: URS, 1974

(APWA, 1969); URS I Study (URS, 1972); and URS II Study (URS, 1973).

The URS study concluded that geographical location, land use, street surface material, and the type of adjacent landscaping were important, in the order given, in explaining the pollutant accumulation rates. The range of values and the number of observations should provide a more realistic picture of the variations than the derived statistics. For example, for land use category, number 10--which is open space--average solids loading of 12 lbs/curb mile/day is not meaningful since only one data point exists. Conclusions drawn from the analysis of this data by URS are presented in Table 3. Following studies, notably by Shaheen, indicate that the local geology and the traffic activities dominate the dynamics of the street surface pollutants. (Shaheen, 1975).

A reexamination of the URS data by Berwick, et.al., using a two-way table analyses of the log-transformed data indicates that differences in land use do not account for much of the observed differences in loadings; that there is little or no effect from increased traffic density; and that regional differences need to be examined further since gross categories of land use and climatic region, particularly for the northeast, do not account for all the difference.

Table 3: Conclusions Related to Loading Rates

a. Loading Rates Are Lowest in:

1. Commercial areas, probably because they are swept frequently
2. Northwest
3. Areas with highest traffic, probably because the removal processes (primarily traffic generated winds) are more active
*4. Tree covered areas; unexpected because it was thought that leaves contributed substantially to loading rates
5. Concrete surfaces

b. BOD_5 Concentrations Are Lowest in:

1. Residential and heavy industrial areas
2. The southwest, probably reflecting the lack of lush vegetation relative to the East Coast
3. Areas with moderate ADT
4. Areas with landscaped buildings, probably reflecting better maintenance
5. On asphalt road surfaces

c. COD Concentrations Are Lowest in:

1. Residential and heavy industry, whereas it is highest in commercial areas; the latter may be due to oil from many parked cars on the street
2. Not significantly different climatologically
3. Areas with moderate traffic (500-5000 ADT)
4. Areas with landscaped buildings
5. Not significantly different between street surface types

d. Ortho Phosphate Concentrations Are Lowest in:

*1. Residential areas; an unexpected finding considering the widespread use of fertilizer on lawns
2. The southwest (highest in southeast), probably reflecting the difference in vegetation or fertilizing practices
3. Areas with moderate traffic (500-5000 ADT)
4. Areas with no landscaping, probably because no fertilizer is used
5. On asphalt surfaces

e. No Conclusions Can Be Obtained From the Total Phosphate Data

f. Nitrate Concentrations Are Lowest in:

1. Heavy industry areas
2. No significant differences climatologically
3. No significant differences between traffic densities
4. Areas without landscaping
5. No significant difference between street surface types

g. No Conclusions Can Be Obtained from the Ammonia Data

Table 3 (continued)

h. Organic Nitrogen Concentrations Are Lowest in:

1. Heavy industry areas
*2. The southeast; and unexpected finding since the southeast contains the most lush vegetation
3. Areas with moderate traffic (500-5000 ADT)
4. Areas without landscaping
5. Asphalt surfaces

i. Cadmium Concentrations Are Relatively Uniform in All Categories

j. Chromium Concentrations Are Lowest in:

1. Residential areas
*2. The northeast; unexpected since the major source of chromium on streets was thought to be chromate salts added to deicing salt as a metal preservative
3. No significant differences with traffic density
4. No significant difference with landscaping
5. On concrete surfaces

k. Copper Concentrations Are Lowest in:

1. Residential areas
2. The southwest
3. Areas with light traffic (<500 ADT)
4. Areas with grass landscaping
5. Not significantly different between street surface types

l. Iron Concentrations Are Lowest in:

1. Not significantly different with land use types
*2. Lowest in the northeast (highest in northwest)
3. Not significantly different with traffic density
4. Not significantly different with landscaping type
5. Not significantly different between street surface types

m. Lead Concentrations Are Lowest in:

1. Heavy industry areas, low also in residential areas; this probably reflects low vehicular traffic
*2. The northeast (highest in the northwest); this may reflect the inhomogeneity of sampling sites
3. Areas with light and moderate traffic
4. Areas with grass landscaping
5. Concrete road surfaces

n. Manganese Concentrations Do Not Vary Greatly Between Categories

Table 3 (continued)

o. Nickel Concentrations Are Lowest in:

1. Residential areas
2. The northeast and southeast
3. Areas with moderate traffic (500-5000 ADT)
4. Areas with grass landscaping
5. Concrete road surfaces

p. Strontium Concentrations Vary Only Slightly Between Categories

q. Zinc Concentrations Are Lowest in:

*1. Heavy industry areas
2. The northeast
3. Areas with light daily traffic (<500 ADT)
4. Not significantly different between landscaping types
5. Concrete surfaces

r. Total Coliform Counts are Lowest in:

1. Heavy industry areas
2. The northwest
3. Areas with heavy vehicular traffic (>15,000 ADT)
4. Areas with grass or no landscaping (and highest in tree covered areas)

s. Fecal Coliform Counts Are Lowest in:

*1. No significant differences between land use categories; unexpected because generally it is thought that pet feces cause higher fecal coliform counts in residential areas
2. The northwest
3. Areas with heavy traffic (>15,000 ADT)
4. No significant differences with landscaping

Generally the trends observed were expected, or, at least, not unexpected. In eight cases the data indicated that preconceived notions were not supported by observations.

* Unexpected findings

Source: URS, 1974

ACCUMULATION OF POLLUTANTS ON STREET SURFACES

A knowledge of pollutant sources and the deposition and accumulation rates of pollutants on street surfaces is necessary for the assessment of the contribution of street surfaces to the total pollutant loading into the receiving waters. With this data, water quality control measures implemented to reduce the pollutant potential of street surfaces can be evaluated for cost-effectiveness. The main body of quantitative information related to the accumulation rates of pollutants has been derived from the sampling programs carried out as part of the studies sponsored by EPA since the early 1970s. Programs in the Bay Area include a monitoring program in Castro Valley which is in its second year, and an earlier program completed in San Jose as part of a street sweeping demonstration study.

The high costs of obtaining site-specific data and the time it takes to obtain such data--EPA's storm and combined sewer program maintains that a minimum of three years of data collection on rainfall, runoff loads, and receiving water impact are necessary--have prohibited extensive data gathering to date.

Dust, dirt and associated pollutants accumulate at variable rates on street surfaces. Sources and mechanisms responsible for and affecting such depositions and accumulations are not directly quantifiable. Inferences can be drawn, however, from information extracted from direct sampling of solids on the street surfaces under various conditions or from direct measurement of flows and pollutant concentrations at the outlets of drainage systems or in the receiving waters. Both sampling methods could also be simultaneously employed to obtain a mass balance which then may allow identification of component sources and dominant variables more accurately. Evaluation of early sampling data have indicated the need for better sampling programs design and for more accurate mass balances.

In order to explain the wide range of values in the data and to provide the urgently needed information for the 208 studies, investigations have attempted, by using various analytical techniques, to formulate predictive equations and derive representative statistics based on interrelationships among pertinent quality variables and various independent variables. Solids composition and rates of accumulation (physical, chemical and biological) were hypothesized to vary as a function of geographical location (climate and geology), land use and activities, average daily traffic, population and income, and adjacent areas as characterized by similar variables (see Table 2). Average nationwide data on pollutant strengths associated with street surfaces are presented in Table 4. The following observations reported in the literature indicate the nature of the information available to date:

- Scattering in data collected from literature is due to variations in methods used for collection and analysis of street surface pollutants. This variance component can be neither eliminated nor evaluated at this time (URS, 1974).

Table 4: Average Nationwide Pollutant Strengths Associated With Street Surface Particulates

Parameter (ppm[a] except as noted)	Mean loading	Minimum loading	Maximum loading	Standard deviation
Total solids, (lb/curb mi/day) (b)	156	3	2,700	370
BOD_5 (b)	70,000[e]	8,500[e]	270,000[e]	80,000[e]
COD (b)	140,000	17,000	530,000	160,000
Ortho PO_4 (b)	1,300	14	6,700	1,400
Total PO_4 (b)	2,900	210	5,400	f
NO_3 (b)	800	20	16,000	2,600
NH_4 (b)	2,600	600	5,400	f
Kjeldahl N (b)	3,000	450	13,000	3,100
Cd (b)	3.4	0	25	3.6
Cr (b)	210	3	760	110
Cu (b)	100	8	290	100
Fe (b)	22,000	2,200	72,000	11,000
Pb (b)	1,800	0	10,000	2,000
Mn (b)	420	100	1,600	220
Ni (b)	35	0	170	38
Sr (b)	21	0	110	21
Zn (b)	370	21	1,100	210
Total Coliforms (no./gram) (d)	2.5×10^6	1.2×10^4	8.6×10^7	g
Fecal Coliforms (no./gram) (d)	1.7×10^5	6.0	1.7×10^7	g
Asbestos (fibers/gram) (c)	160,000	0	770,000	180,000
Rubber (c)	4,600	500	11,000	2,600
p, p-DDD (d)	0.082	0.0002	0.27	0.08
p, p-DDT (d)	0.075	0.0004	0.38	0.12
Dieldrin (d)	0.028	0.003	0.074	0.028
Endrin (d)	0.00028	0	0.0022	0.00073
Lindane (d)	0.0022	0	0.019	0.0063
Methoxychlor (d)	0.50	0	3.1	1.1
Methyl parathion (d)	0.0024	0	0.022	0.0073
PCB's (d)	0.77	0.07	2.3	0.76

[a]ppm = microgram of pollutant per gram of total dry solids
[b]URS (1974) — a compilation of the results of many studies
[c]Shaheen (1975)
[d]Sartor and Boyd (1972
[e]BOD = ½ COD (see Colston, 1974
[f]Few samples (less than 10)
[g]Very large variance

Source: Pitt, 1976

- The data follow a log-normal distribution and are highly skewed. Therefore, simple arithmetic mean and standard deviation calculated to summarize these data are extremely misleading. Median is a better measure of the expected values than the arithmetic mean (Berwick, et. al., 1977).

- Simple conceptual models and use of regression analysis fail to explain the data due to extreme scatter (Singh, 1977).

- No statistically significant relationships can be found between antecedent days of accumulation and load in any land use or climatic category (URS, 1974; Colston, 1974; Whipple, 1976; Hammer, 1976; Singh, 1977; Berwick, et. al., 1977).

- Factor analysis techniques should be used to extract information from the existing data. However, this kind of analysis requires more data (URS, 1974).

- With the present data base, detailed predictive models are not feasible; therefore, loading rates should be analyzed with exploratory rather than predictive data analyses. Variation of solids and pollutant accumulation as a function of land use, traffic and geography is best explored in two-way tables (Berwick, et. al., 1977). The present status of the knowledge on street surface pollutant sources and rates ranges widely. One extreme claim is made that the observed loadings in receiving waters might not reflect any areal buildup but rather are related to more local, microscale erosion (Hammer, 1976). However, available data and the derived statistics, used with caution, will provide a workable range for preliminary assessments.

ACCUMULATION RATES

Relationship to Loading Rates

Street cleaning performance is closely related to the initial loading on the streets before cleaning and the solids accumulation rates. Mean, minimum and maximum pollutant loadings based on nationwide averages were presented in Table 4. Nationwide averages of the estimated street surface accumulation rates are presented in Table 5. Pitt remarks that these accumulation rates, coupled with the pollutant loadings from Table 4, can be used to estimate the probable range of street surface contaminant accumulation conditions. However, site-specific measurements should be used to determine more accurate accumulation estimates for designing street cleaning or runoff treatment programs.

Table 5: Estimated Street Surface Accumulation Rates, LB/Curb Mile/Day, Except as Noted

Parameter	Nationwide mean
Total dry solids	156
BOD_5	11
COD	22
Ortho PO_4	0.2
NO_3	0.1
Kjeldahl N	0.5
Cr	0.003
Fe	3.4
Pb	0.28
Zn	0.06
Asbestos (fibers/curb mile/day)	1×10^{10}
Rubber	0.7
p,p-DDT	1×10^{-5}
PCBs	1×10^{-4}

Source: Pitt, 1976

Table 6: Average Total Solids Accumulation Rate

Test Area	Loading Immediately After Cleaning (lb/curb-mile)	Accumulation Rate for Period of Time Since Last Cleaned (lb/curb-mile/day)		
		0 → 2 days	2 → 10 days	10 → 30 days
Keyes-good asphalt	290	17	13	11
Keyes-oil and screens	1800	20	19	16
Tropicana-good asphalt	130	17	13	11
Downtown-good asphalt	170	10	9	9
Downtown-poor asphalt	780	20	20	20

Source: Pitt, 1979

Average total solids accumulation rates in San Jose are shown in Table 6 for different street surface types. A maximum of 20 pounds per curb-mile per day is indicated for poor asphalt surface. This figure is quite lower than the national average of all data which is 156 pounds and also lower than the national average of 150 pounds for asphalt street surface type.

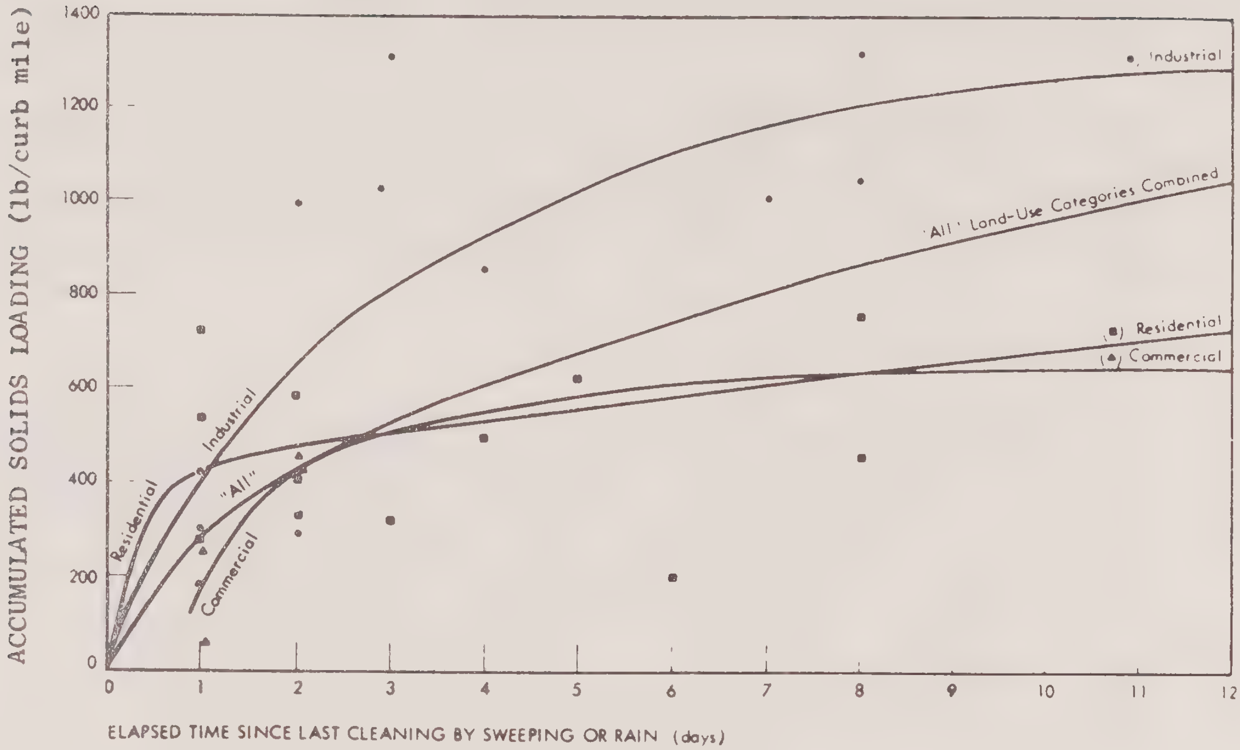
Relationship to Days before Last Cleaning

Since street cleaning performance is closely related to the accumulation rates and the initial loading, the relationship with the number of days elapsed since last sweeping or rainfall has been investigated. Various curves were fitted by the least squares method to the national loading intensity data, and to data grouped into residential, industrial, and commercial land uses. Best fitting curves for each land-use category are shown in Figure 4 from the Sarter and Boyd study (URS, 1972). The consensus is that accumulation over time is a nonlinear process, and that the bulk of the material accumulates within the first day. The accumulation tapers off after the first day and approaches a constant value. The curve-fitting attempt seems to validate the above and gives rise to graphs with a generally concave downward shape. J.B. Gilbert & Associates reevaluated the Sarter and Boyd data and came up with best-fit regression equations for each of the land use categories (J.B. Gilbert & Associates, 1978).

Table 7 presents the best-fit equations. As seen in the table, approximately 70-80 percent of the variation in accumulation rates is not explained by antecedent days. Sarter and Boyd's best-fit equation for residential land use also indicates increasing accumulations after a week. Berwick, et. al., remarked that this process is not well-modelled by a simple first-order process, and suggested that a second-order accumulation model appears to be more appropriate. Since their data and analysis is not presently available, improvement achieved by a second-order process over the first-order curves presented in Table 6 is not known.

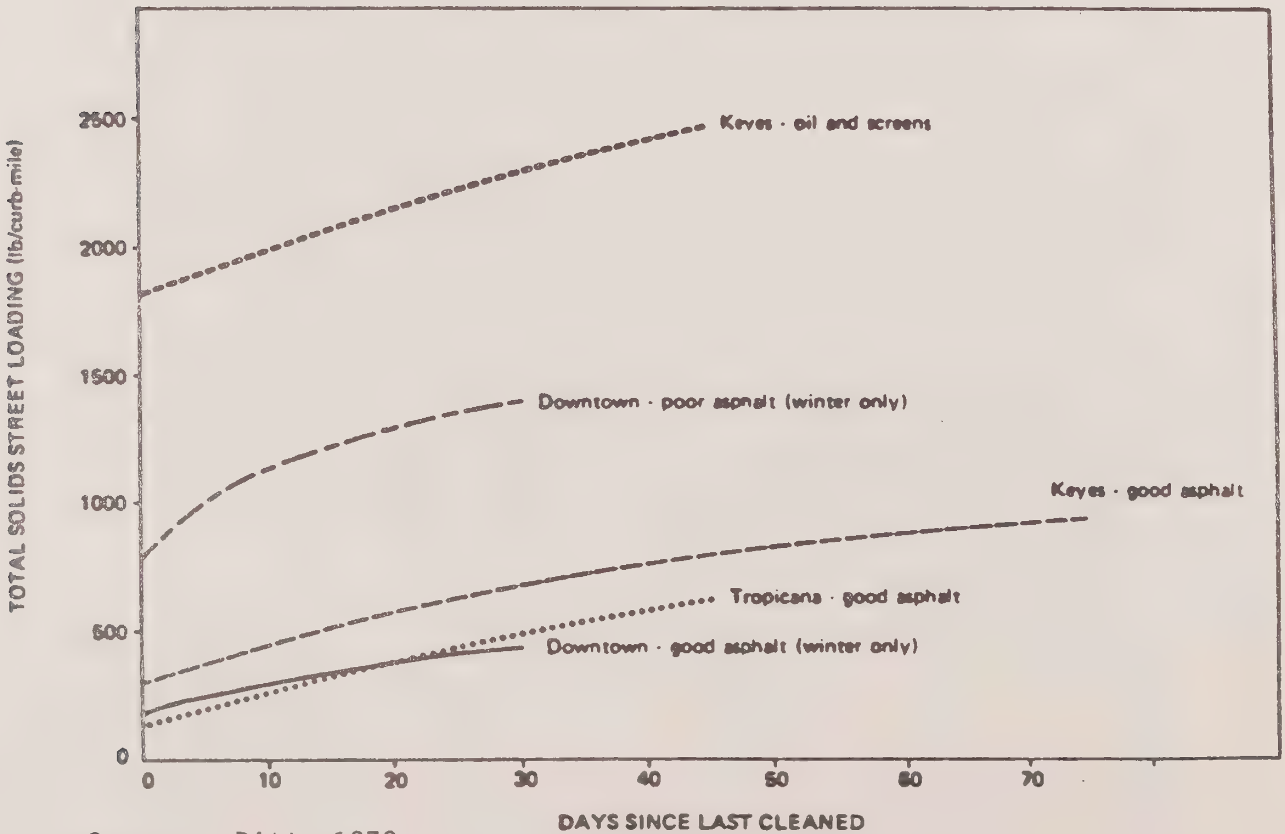
Total solids accumulation curves for the San Jose test areas are shown in Figure 5. Pitt remarks that first, second and third order polynomial curves with and without logarithmic transformations were fitted to the data; and correlation coefficients ranging from 0.35 to 0.9 were obtained. Loadings are quite different for different test areas, but accumulation rates follow similar trends. Curves indicate no leveling off of the loadings even though accumulation rates decreased with time.

Figure 4: Time Since Last Cleaning vs. Solids Loading



Source: URS, 1972

Figure 5: Total Solids Accumulation Since Last Cleaned (All Seasons Combined)



Source: Pitt, 1979

Table 7: Solids Accumulation Versus Antecedent Days

Land Use	Sarter & Boyd (1972)	J.B. Gilbert & Assoc.
Residential	$S = 426\ e^{0.0565\ t}$ index = 0.17	$S = 153\ t^{0.377}$ index =0.23
Industrial	$S = \dfrac{t}{0.00187 + 0.000601\ t}$ index = 0.32	$S = 163\ t^{0.545}$ index=0.34
Commercial	$S = 694 - \dfrac{519}{t}$ index = 0.88	$S = 62.0\ t^{0.457}$ index= 0.30

S = solids accumulated, lb./curb-mile
t = time since last rainfall or street cleaning (days)

WASHOFF PROCESS

The washoff equation currently used in modelling the amount of pollutants washed off a street surface, dP, in any time interval, dt, assumes that dP is proportional to the amount of pollutant remaining on the street surface:

$$\frac{dP}{dt} = KrP$$

which integrates to -Krt

$$P_o - P = (1-e^{-Krt})$$

where P_o = initial loading in pounds
P = pounds remaining after time, t
K = constant
t = time
r = runoff rate
P_o-P = pounds washed away in time, t

The experiments carried out in Bakersfield, California by URS Research Company (URS, 1972) using rainfall simulations indicated that the constant, K, is dependent on rainfall runoff rate and that a uniform runoff of 0.5

inches per hour will wash off 90 percent of the initial pollutant load in one hour. The equation then becomes:

$$P_o - P = P_o\ (1-e^{-4.6rt})$$

The Bakersfield study also indicated that the constant, k, is independent of particle size.

REMOVAL OF POLLUTANTS BY STREET SWEEPERS

Performance of existing street sweeping programs have been investigated by URS Research Company (URS, 1972). Variables quantified in controlled tests were as follows:

- equipment type
- particle size distribution
- broom types
- initial loadings on the street
- number of equipment passes
- location of particulates on the street
- presence of parked cars

Three types of sweepers commonly in use are the mechanical 3- or 4-wheel sweeper, regenerative air system sweeper, and the vacuum sweeper. Operating speeds of these sweepers range from 4 to 8 mph. Although all three types exhibit high efficiency in removing particles greater than ¼ inches, efficiency of removal varies for each type for smaller particle sizes. Tests conducted under optimum machine operating conditions have shown direct relationships between cleaning efficiency, particle size, initial street surface loading, and number of equipment passes over the same area. Tables 8 and 9 summarize these relationships for vacuum and mechanical sweepers. The data indicate that the equipment is more efficient for larger particle and high initial loads. The effect of running a sweeper for a second and third pass over the same area results in a sharp reduction in removal efficiency. This decreased efficiency is due probably to:

- reduced amount of residual load on the street;
- higher concentrations of small particles in the residual load; and
- more even distribution of the load across the street surface.

Figure 6 compares street surface particle-size distributions before and after a single pass with mechanical sweepers. When the size distributions for pollutants existing on the street are known, removal rates can be calculated. Figures 2 and 3 show nationwide average size distributions. Table 10 shows calculated removal efficiencies of various street cleaning programs.

Table 8: Removal Efficiency for Vacuumized Sweeper at Different Initial Particulate Loadings and for Different Numbers of Passes

Size range	20→200 lb/curb mi			200→1,000 lb/curb mi			1,000→10,000 lb/curb mi		
	1 pass	2	3	1	2	3	1	2	3
44→74μ	3	6	9	20	36	49	70	91	97
74→177μ	50	75	88	60	84	94	75	94	99
177→300μ	50	75	88	60	84	94	80	96	99
300→500μ	60	84	94	65	88	96	70	91	94
750→1,000μ	50	75	88	60	84	94	70	91	97

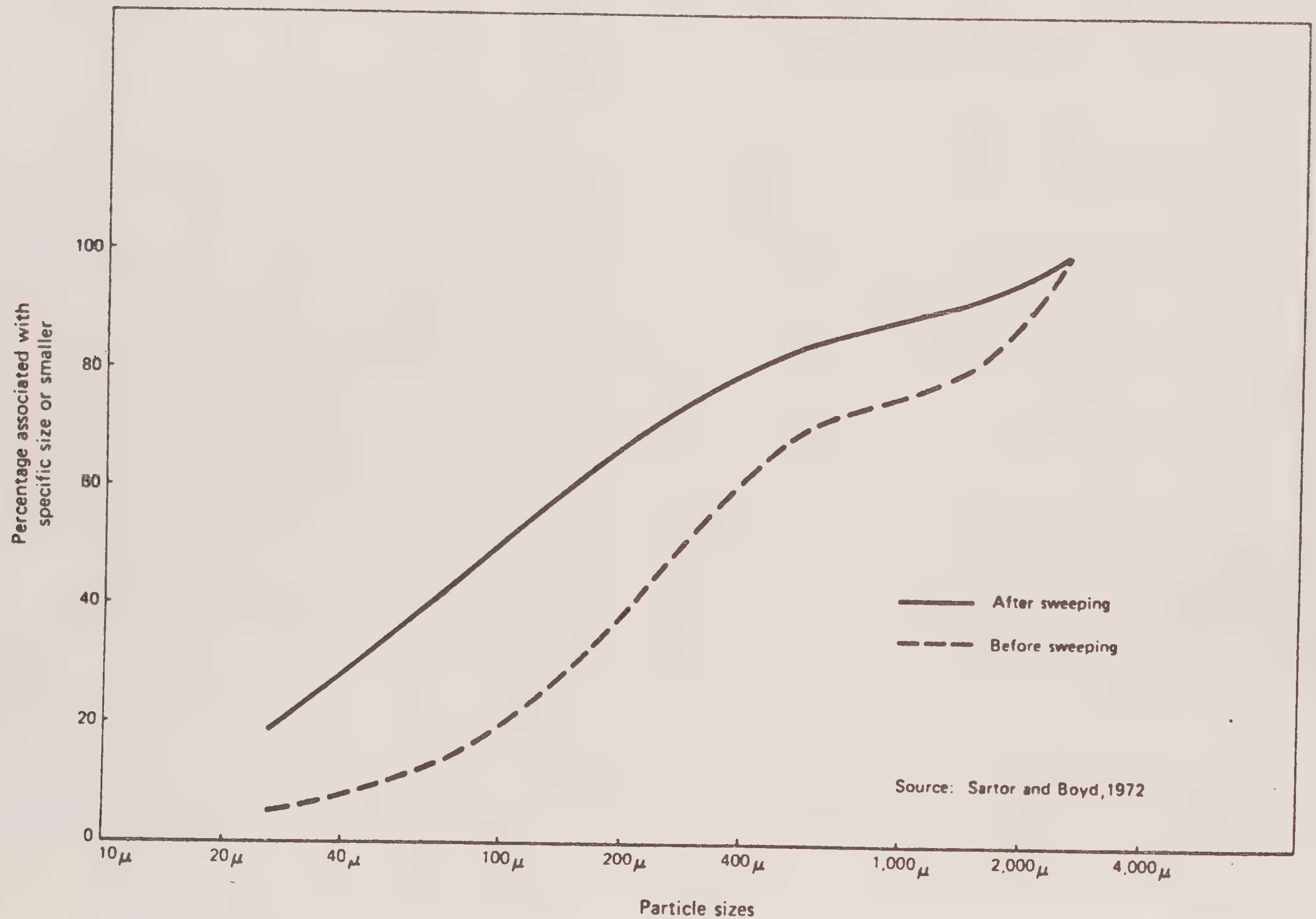
Source: Clark and Cobbin, 1963

Table 9: Mechanical Sweeper Efficiency for Different Equipment Passes

Size range	180→1800 lb/curb mile		
	1 pass	2 passes	3 passes
<43μ	15	28	39
43→104μ	20	36	49
104→246μ	50	75	88
246→840μ	60	84	94
840→2,000μ	65	88	96
2,000μ→1/4 in.	80	96	99

Source: Sartor and Boyd, 1972

Figure 6: Particle (¼inch) Size Distribution Before and After Sweeping Tests (Atlanta, Tulsa, Phoenix, and Scottsdale Tests Only)



Source: Pitt, 1976

Table 10: Removal Efficiencies for Various Street Cleaning Equipment

	Total Solids	BOD_5	COD	KN	PO_4	Pesticides	Cd	Sr	Cu	Ni	Cr	Zn	Mn	Pb	Fe
Vacuum Sweeper 1 pass; 20→200 lb/curb mile total solids	31	24	16	26	8	33	23	27	30	37	34	34	37	40	40
2 passes	45	35	22	37	12	50	34	35	45	54	53	52	56	59	59
3 passes	53	41	27	45	14	59	40	48	52	63	60	59	65	70	68
Vacuum Sweeper 1 pass; 200→1,000 lb/curb mile total solids	37	29	21	31	12	40	30	34	36	43	42	41	45	49	59
2 passes	51	42	29	46	17	59	43	48	49	59	60	59	63	68	68
3 passes	58	47	35	51	20	67	50	53	59	68	66	67	70	76	75
Vacuum Sweeper 1 pass; 1,000→10,000 lb/curb mile total solids	48	38	33	43	20	57	45	44	49	55	53	55	58	62	63
2 passes	60	50	42	54	25	72	57	55	63	70	68	69	72	79	77
3 passes	63	52	44	57	26	75	60	58	66	73	72	73	76	83	82
Mechanical Sweeper 1 pass; 180→1800 lb/curb mile total solids	54	40	31	40	20	40	28	40	38	45	44	43	47	44	49
2 passes	75	58	48	58	35	60	45	59	58	65	64	64	64	65	71
3 passes	85	69	59	69	46	72	57	70	69	76	75	75	79	77	82
Flusher	~30	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
Mech. Sweeper followed by a flusher	~80	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)

(a) 15→40 percent estimated
(b) 35→100 percent estimated

Source: Pitt, 1976

The effects of sweeping patterns, broom speeds and sweeper speed on removal efficiency is shown in Figure 7.

The street surface contaminants are not distributed uniformly across the streets. Seventy-eight percent of solids are within 6 inches from the curb. This is particularly so where on-street parking is heavy. The effectiveness of a sweeping program is reduced in direct proportion to the obstructed curb mileage over the total curb-miles to be swept.

For the San Jose study, several street cleaning programs using various equipment (4-wheel mechanical street cleaner, state-of-the-art mechanical street cleaner, and vacuum-assisted mechanical street cleaner) and level of effort were investigated under "real-world" conditions. The following conclusions are reported (Pitt, 1979):

- San Jose tests indicate that effectiveness of street sweeping is less than what was found under the earlier controlled tests.

- Type of equipment used and the number of passes do not account for the initial loadings in various test areas. Area conditions largely control the loadings.

- Amount of solids removed is more a function of the test area than the street cleaning program.

- Selection of the specific type of street cleaning equipment is less important than the characteristics of the area to be cleaned.

- Vacuum sweeping did not significantly change the median particle size or the pollutant loadings on the street after sweeping with respect to other types of equipment.

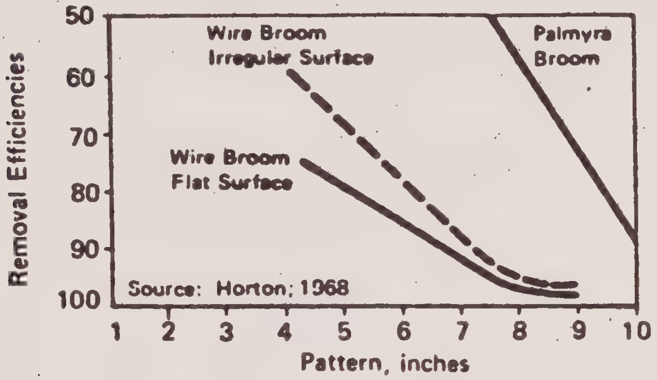
- Larger particles have higher removal efficiencies under all test conditions (Figure 8).

- Mercury, cadmium, zinc, lead, Kjeldahl nitrogen, and total ortho-phosphates are higher in concentrations at smaller particle sizes. Copper and chromium, on the other hand, are at lowest concentrations at smaller particle sizes.

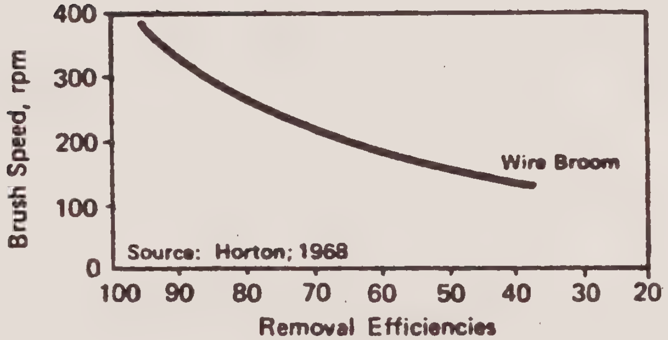
- Overall removal efficiency, for good asphalt surfaces was 40 percent; and for the oil and screens areas it was 12 percent.

- On good asphalt streets, parked cars affect the loading distribution much more radically than on the rougher streets.

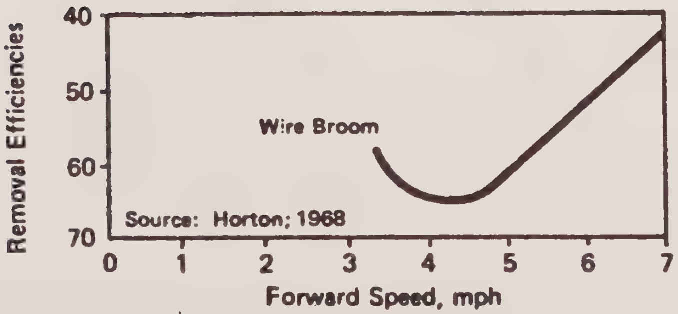
Figure 7: Effect of Sweeping Pattern, Brush Speed and Sweeper Speed in Removal Efficiencies



EFFECT OF PATTERN ON RESIDUAL DEBRIS



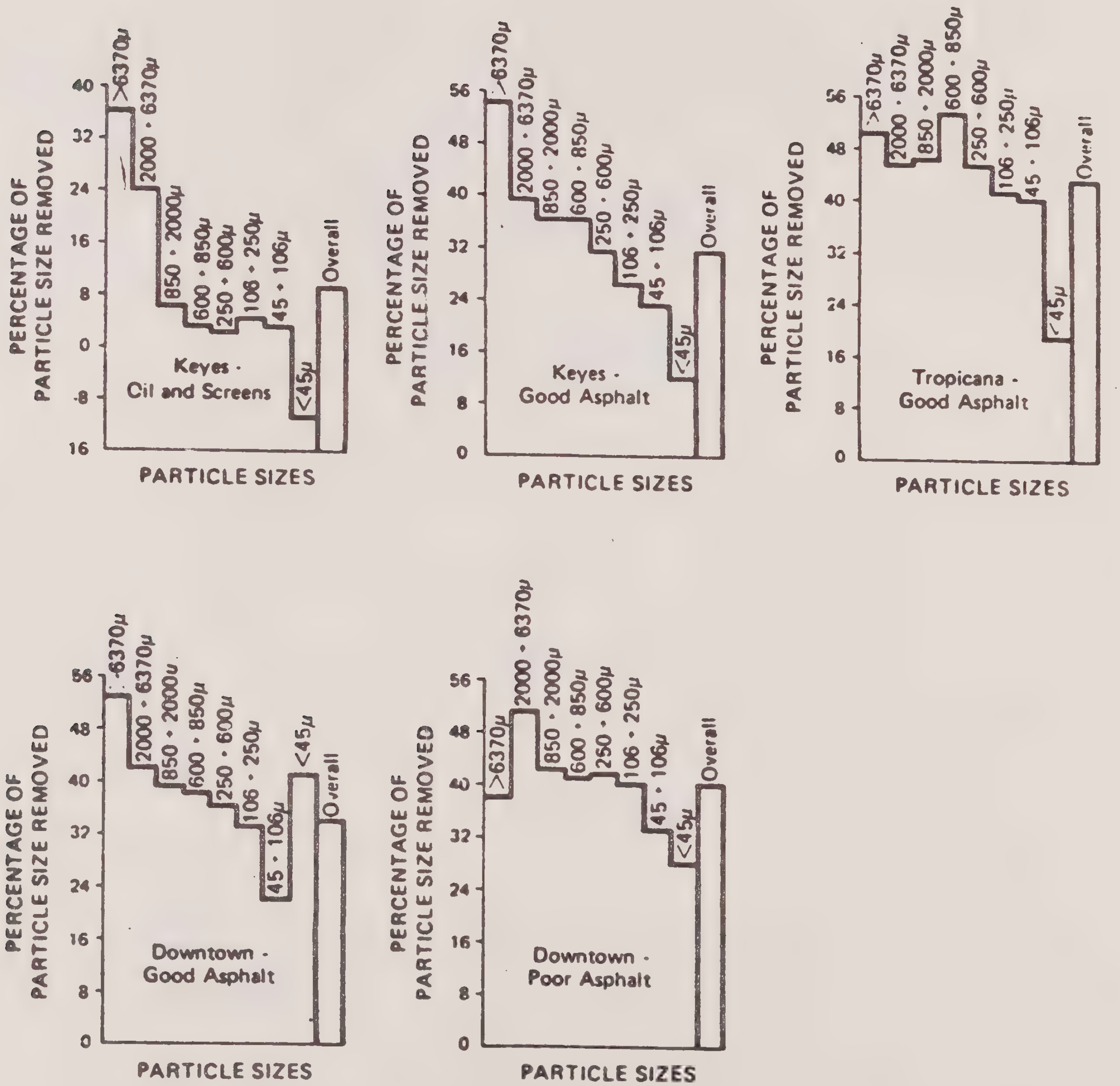
DEBRIS PICKUP VS. BRUSH SPEED



EFFECT OF SWEEPER SPEED ON RESIDUAL DEBRIS

Source: Pitt, 1976

Figure 8: Total Solids Removal by Particle Size



Source: Pitt, 1979

SUMMARY

The following major points related to street surface pollutant accumulation and removal can be summarized from the literature findings reported in this memorandum.

- The types of pollutants found on street surfaces and their intensity at a given time vary as a function of interrelated variables. Local geographic conditions and motor vehicle wear and emissions seem to be responsible for most of the pollutants residing on street surfaces. Street abrasion and surrounding areas also contribute additional amounts. Most heavy metals are deposited from spills, leaks, wear, and combustion emissions from motor vehicles. Nitrogen and phosphorus mostly originate from non-street areas.

- Accumulation rates vary widely depending on factors such as geography, street surface type, land use, traffic and parking conditions, and street cleaning activities. The present data base does not allow reliable categorical description of quantities and rates. Conceptual models and curve-fitting techniques applied to the available data have not produced reliable predictive models. Therefore, local monitoring is necessary in order to characterize the nature of the pollutants so that sound street-cleaning programs can be designed. However, the available nationwide data provide a workable range of conditions for regional assessments.

- Most urban runoff models use an exponential decay relationship for the rainfall washoff of pollutants from the street surfaces. The assumption is that the amount of pollutant washed off is proportional to the amount remaining and the runoff rate. Limited field studies indicate that washoff process can be suitably represented by an exponential decay relationship.

- The efficiency of state-of-the-art motorized street sweepers in removing pollutants from street surfaces varies mainly as a function of initial street loadings, distribution of loadings across the street surface, particle size distribution and associated pollutant composition, and intensity of previous cleaning.

  The type of street cleaner used is less important in determining the removal efficiency of the cleaning operation than the characteristics of the area to be cleaned. The type of street surface and its condition, and traffic activities affect the loadings, and their distribution which in turn affect the removal efficiency of the equipment.

  Sweepers are generally more effective at removing larger particles than smaller particles; and as a result, the residual of small particles tends to increase with time. Types of pollutants and their concentrations correlate with specific particle sizes. Higher concentrations of most heavy metals seem to be associated with smaller particle sizes. Therefore a knowledge of particle size and pollutant

concentrations is necessary for the design of control procedures to achieve specific pollutant removals.

This information will be used as the basis for a subsequent analysis for the cost and effectiveness of street cleaning programs in Bay Area communities. This analysis will be presented in a subsequent technical memorandum.

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WQ/TECH MEMO #37/November 30, 1979
Bruce D. Fitting

WATER QUALITY MANAGEMENT PLAN

WATERCOURSE PROTECTION ORDINANCES

Technical Memorandum No. 37

November 30, 1979

Watercourse protection--or riparian--ordinances are one form of local policy serving to prevent water quality degradation. As such, they fit in with the Federal and State regulatory scheme that most people view as serving this purpose. Similar to Federal law, local watercourse protection ordinances express a kind of limitation on discharges to receiving bodies of water, and these limits are enforced via a permit system. There is also a resemblance to Federal Army Corps of Engineer regulations on obstruction of navigable waterways. And, like the State's Porter-Cologne Act, protection of beneficial uses is important in watercourse protection ordinances, particularly those aiming to preserve streambanks and riparian habitat. Some of the local ordinances, however, are heavily flavored with direct land use considerations, unlike Federal and State policy.

There are currently many watercourse protection ordinances in effect in the Bay Area. Three additional ordinances are being proposed, with one of these supplementing one of the existing ordinances. Because the local policies being expressed by these laws are not identical, it is useful to take a closer look at them to see what is actually involved.

Two of the existing ordinances are in Napa County ("Ordinance No. 447 - Ordinance of the Board of Supervisors of the County of Napa, State of California, Providing for the Control Through Licensing of Works Changing the Hydraulic Characteristics of Certain Watercourses Within the County of Napa and Protecting the Riparian Cover Within Specified Distances Thereof..."); and Sonoma County ("Ordinance No. 1108, as amended by Ordinance No. 1300 - An Ordinance Providing for the Control of Water Courses and Natural Drainage...") Sonoma adopted its ordinance in 1968, later amending it in 1970, and Napa passed its in 1974. These two ordinances are illustrative of the set and will be described.

The two laws are quite similar. Both have the main purpose of prevention of flooding, and both are administered by the County flood control agency. Napa County expresses the further purposes of protection of riparian cover and habitat, and promotion of the county's economic well-being. Both ordinances prohibit, in the absence of a valid permit, the alteration of streamflows within the county, whether by obstruction, deposition of materials in the watercourse, excavation, or streambank activities. Permit application and issuance procedures are established, and fees are authorized. Inspection and enforcement are also covered. Both ordinances allow the administering agency to collect a performance bond from the permit applicant.

The three ordinances now under preparation in the region are a bit different than the laws existing in Napa and Sonoma Counties. Two of the three, those for Sonoma County ("Draft Riparian Ordinance" - September 1, 1978) and Solano County ("Ordinance No. ______ - An Ordinance Amending Chapter 28 of the Solano County Code by Adding Section 28 - ______ Thereto Entitled 'Watercourse Environment Areas'" - October 19, 1979), are being considered as amendments to existing zoning regulations. As such, they focus more on the permitted uses of land within designated riparian corridors--rather than prohibitions on obstructing the natural streamflow. For example, the Solano Draft defines two distinct strips of land alongside of and including a watercourse, and it specifies the allowed and prohibited uses in each of these subareas. The proposal also includes a set of principles and standards for development within the riparian corridors. Permit procedures and enforcement considerations are also included. The Sonoma County draft is similar. Finally, both expressly state water quality protection as a purpose.

The third proposed ordinance is by Alameda County ("Ordinance No. ______ - An Ordinance Adding Chapter 7 to Title 3, Chapter 6 of the Alameda County Ordinance Code and Entitled Watercourse Protection Ordinance of Alameda County" - October 19, 1979). This draft is more akin to the existing ordinances in Napa and Sonoma Counties, being basically of the flood-prevention type. It does demonstrate its roots in 208 planning, however, by expressing water quality protection as a purpose and by underscoring the responsibility of all dischargers to comply with applicable water quality standards and regulations. The one land use feature of this proposed ordinance is a ban on the construction of structures for human habitation within 20 feet of any watercourse. Features of these five ordinances are summarized in the table on the following pages.

ABAG staff would like to see the Bay Area's cities and counties develop and consider watercourse protection ordinances. Ideally, such an ordinance would include the following features:

1. Prohibited and allowed uses of watercourses identified in the ordinance. Permit procedures and development standards would also be included.

2. Definition of a riparian zone or zones along the watercourses in connection with the prohibited and allowed uses of the zone(s). Permit procedures and development standards would be included as well.

3. Inspection authorization.

4. Enforcement provisions, including bond requirements and penalties for ordinance noncompliance such as notices to violators, direct abatement

of the problem by the administering agency, fines on the violators, and potential imprisonment of the violators.

In sum, staff recommends an ordinance which seeks both to prevent flooding as well as protect an identified streambank zone or zones. Administration of such an ordinance would need to be divided between the jurisdiction's flood control public works and planning departments. This type of dual purpose ordinance would, in the opinion of ABAG staff, provide maximum water quality benefits.

JURISDICTION	ALAMEDA COUNTY	NAPA COUNTY	SOLANO COUNTY	SONOMA COUNTY	SONOMA COUNTY
DATE OF ORDINANCE ADOPTION	Draft (10/79)	1974	Draft (10/79)	1968 amended in 1970	Draft (9/78)
ADMINISTERING AGENCY	Alameda County Flood Control and Water Conservation District	Napa County Flood Control and Water Conservation District; Napa County Conservation Development and Planning Commission	Solano County Planning Department	Sonoma County Water Agency	Sonoma County Board of Zoning Adjustments
BASIC PURPOSES OF THE ORDINANCE	Prevention of flooding, drainage impairment and water quality degradation	Prevention of flooding; protection of riparian cover and habitat	Preservation of water quality and riparian habitat; control of erosion and flooding; promotion of wise land use	Prevention of flooding; control of drainage	Prevention of erosion; implementation of several county General Plan goals and policies
PROTECTED WATERCOURSES IDENTIFIED	No	No	Yes	No	Yes (in General Plan)
PROHIBITED/ALLOWED USES OF WATERCOURSES IDENTIFIED	Yes	Yes	Yes	Yes	No. Covered in 1968-70 ordinance.
PERMIT REQUIRED FOR PROHIBITED/ALLOWED USES	Yes	Yes	Yes	Yes	No. Covered in 1968-70 ordinance.
DEVELOPMENT STANDARDS FOR PROHIBITED/ALLOWED USES DEFINED	No	Yes	Yes	No	No
PROHITITED/ALLOWED USES OF RIPARIAN ZONE(S) DEFINED	No	No	Yes	No	Yes
PERMIT REQUIRED FOR PROHIBITED/ALLOWED USES	No	No	Yes	No	Yes
DEVELOPMENT STANDARDS FOR PROHIBITED/ALLOWED USES DEFINED	No	No	Yes	No	Yes

JURISDICTION	ALAMEDA COUNTY	NAPA COUNTY	SOLANO COUNTY	SONOMA COUNTY	SONOMA COUNTY
BOND REQUIRED	Discretionary	Yes	No	Discretionary	Yes
INSPECTION AUTHORIZED	Yes	Yes	Yes	Yes	Yes
ENFORCEMENT BY...					
NOTICE TO VIOLATOR	Yes	Yes	Yes	No	Yes
ABATEMENT BY AGENCY	Yes	Yes	Yes	Yes	Yes
FINE ON VIOLATOR	Yes	Yes	Yes	Yes	Yes
IMPRISONMENT	Yes	Yes	Yes	Yes	Yes

WQ Tech Memo No. 38
P. Russell

REGIONAL EVALUATION OF STREET SWEEPING AS A WATER QUALITY CONTROL MEASURE

Technical Memorandum No. 38
December 1979
Revised April 15, 1980
Revised May 20, 1980

A. INTRODUCTION

This technical memorandum evaluates the opportunity for reducing washoff of street solids into receiving waters by adjusting sweeping schedules. The amount of solids washoff depends upon the rainfall intensity and pattern, the accumulation rate and load of solids on the street surface, and the efficiency and frequency of street sweeping. A solids washoff model was used which incorporated these factors to predict the performance of various street sweeping programs. Field data were used in the model for each location examined to supply the appropriate values of street solids build-up, sweeping efficiency, and rainfall sequence. Various sweeping frequencies were tested and each potential program's effectiveness was expressed as the unit cost of preventing a pound of solids from washing off. This objective of minimizing solids washoff emphasizes water quality benefits. The relative importance of street surfaces as a source of pollutants entering San Francisco Bay is discussed elsewhere (Yúcel and Russell, 1980).

Five geographical areas were examined using the solids washoff model: North Alameda County (Alameda, Oakland, and San Leandro); Mid Alameda County (Castro Valley and Hayward); South Alameda County (Fremont, Newark, and Union City); City of Oakland; and City of San Jose. The model output applies to these areas as a whole and may not be representative of sub-sections where non-average conditions occur. Other areas in the San Francisco Bay Region may have special circumstances as well, making these results inapplicable to them as the model output is quite sensitive to peculiarities of the input values. The Alameda County input data was supplied by Alameda County Flood Control and Water Conservation District while San Jose's input was drawn from Pitt's street cleaning study and the Surface Runoff Management Plan for Santa Clara County (Pitt, 1979; County of Santa Clara, 1977).

B. SOLIDS WASHOFF MODEL

A Fortran computer program was written to model street solids accumulation and removal processes. A listing of the computer program is given as Appendix A. Lines 354 through 377 of the listing are the input data for the San Jose runs. Although street sweepers are considered here, the solids washoff model may be applied to any street cleaning equipment usage for which the cleaning efficiency is known.

The computer model is essentially a street solids accounting algorithm which looks at two or four years of rainfall record, day by day, and keeps track of the amount of solids on the street, the amount washed off and the amount swept up. Figure 1 is a flow chart showing the logic of the solids washoff model. As the core of the program, this set of steps is run for each land use at each location over the range of sweep frequencies of interest. In this analysis sweep periods of once every 1, 2, 4, 7, 11, 16, 22, 29 and 37 days were examined. As the program steps through each day it first adds an incremental amount of solids to the street as is characteristic of that location and land use. Then if a rainfall occurs on that day greater than 0.2 in./day, the solids washoff is computed and tallied into a cumulative total for that season. If a rainfall of at least 0.2 in./day does not occur, the program determines whether street sweeping is scheduled or not. If it is, the amount swept up is computed on the basis of the sweeping efficiency characteristic for that location and land use. Thus sweeping is only done on scheduled days having minor or no rainfall. If strict adherence to the sweep period would have the sweeper operate on a Saturday or Sunday, the sweeping is postponed until the following Monday, provided no significant rain occurs on that Monday. If either a sweeping or significant rainfall occurs, the street solids load is reduced by the amount swept up or washed off. Because of the regular occurrence of weekends and their disruption of the normal sweep periodicity, the model was run seven times consecutively, each beginning on a different day of the week, so that average results could be obtained. In addition to the nine sweep frequencies that were examined for each location and land use, the maximum possible amount of washoff was determined by running the model without any sweeper operation. From this worst case result is subtracted the washoff occurring with each of the sweep frequencies to determine the amount of washoff prevented. The relationship of sweep frequency to washoff forgone is the model output of interest and is expressed as cost per pound of solids prevented from washing off. Generally for a given location and land use, the unit cost of preventing solids from washing off increased linearly with increasing sweep frequency.

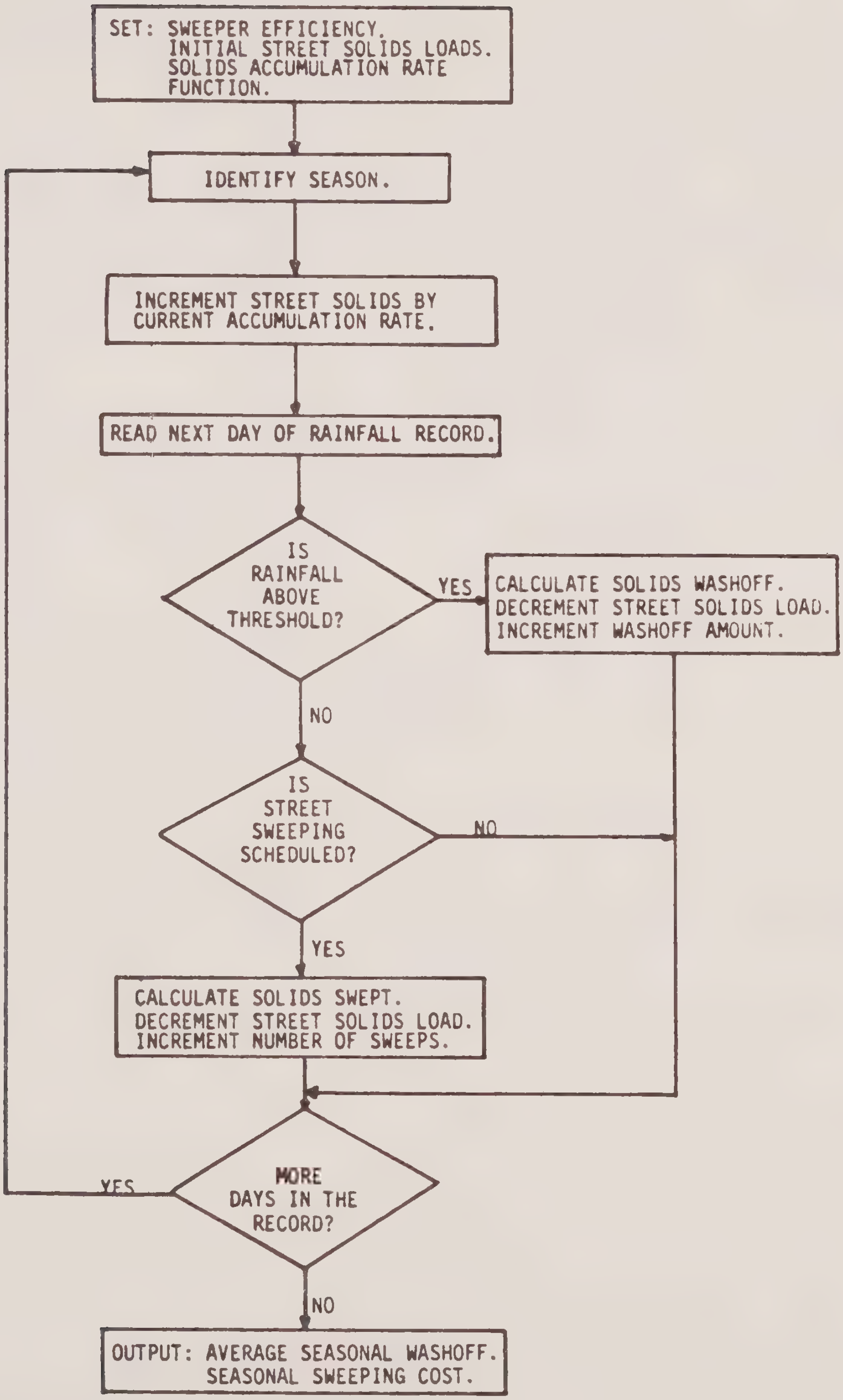
The rainfall records at Hayward from October 1, 1969 through September 30, 1971 and at San Jose from October 1, 1969 through September 30, 1973 were used as typical for the areas under study in terms of rain frequency, intensity and duration. The Hayward record was adjusted upward 10% for use with the City of Oakland and North Alameda County and downward 10% for South Alameda County. The San Jose data were applied unadjusted to the City of San Jose. The seasonal rainfall statistics averaged over the water years used are given for the five areas on Table 1. Daily rains of less than 0.2 in./day were assumed not to cause solids washoff and their contribution to the seasonal rainfall is not included on Table 1.

The input parameters for each location and land use examined are presented on Table 2. The model initializes the street solids inventory for a run with the average solids load before sweeping, then increments it daily using the solids accumulation rate function. The street solids inventory is reduced upon sweeping using the following formula:

$$SR = SL \times (1 - eff)$$

where SR is the solids remaining after street sweeping, SL is the pre-sweep

Figure 1



SOLIDS WASHOFF FLOW DIAGRAM

TABLE 1

RAINFALL INPUT DATA

		(Water Years 1969-71)*		
Season	Location	Number of Rain Days	Seasonal Rainfall (in.)	Average Rain (in/day)
September & October	Oakland	2.5	1.6	0.65
	North Alameda Co.	2.5	1.6	0.65
	Mid Alameda Co.	2.5	1.5	0.59
	South Alameda Co.	2.5	1.3	0.53
November - March	Oakland	30.0	23.4	0.78
	North Alameda Co.	30.0	23.4	0.78
	Mid Alameda Co.	29.5	21.2	0.72
	South Alameda Co.	28.5	18.9	0.66
September - March	San Jose	22.8	11.5	0.51
April - August	Oakland	2.5	1.0	0.40
	North Alameda Co.	2.5	1.0	0.40
	Mid Alameda Co.	2.5	0.9	0.37
	South Alameda Co.	2.0	0.7	0.37
	San Jose	0.5	0.2	0.36

*San Jose entries are for water years 1969-73.

TABLE 2

North Alameda County (Alameda, San Leandro and Oakland)

Sweeping Cost = $15.15/curb-mile/pass

Residential Land Use:

Size = 1420 curb miles
Average solids load before sweeping = 587 lb/curb mile
Solids accumulation rate in lb/curb mile/day = (-0.0667 x current solids load) + 44.31 lb/curb mile/day
Sweeper efficiency = 20.7%

Commercial Land Use:

Size = 128 curb miles
Average solids load before sweeping = 170 lb/curb mile
Solids accumulation rate in lb/curb mile/day = (-0.0667 x current solids load) + 41.29 lb/curb mile/day
Sweeper efficiency = 4.0%

Industrial Land Use:

Size = 283 curb miles
Average solids load before sweeping = 2100 lb/curb mile
Solids accumulation rate in lb/curb mile/day = (-0.0667 x current solids load) + 212.81 lb/curb mile/day
Sweeper efficiency = 16.0%

Mid Alameda County (Castro Valley and Hayward)

Sweeping cost = $9.46/curb mile/pass
Average solids load before sweeping = 636 lb/curb mile
Solids accumulation rate in lb/curb mile/day = (-0.0667 x current solids load) + 59.92 lb/curb mile/day
Sweeper efficiency = 18.4%

Residential Land Use:

Size = 138 curb miles

Commercial Land Use:

Size = 29 curb miles

Industrial Land Use:

Size = 36 curb miles

TABLE 2 (Cont'd)

South Alameda County (Fremont, Newark and Union City)

Sweeping cost = $6.34/curb mile/pass
Average solids load before sweeping = 636 lb/curb mile
Solids accumulation rate in lb/curb mile/day = (-0.0667 x current solids load) + 59.92 lb/curb mile/day
Sweeper efficiency = 18.4%

Residential Land Use:

Size = 729 curb miles

Commercial Land Use:

Size = 82 curb miles

Industrial Land Use:

Size = 74 curb miles

City of Oakland

Sweeping cost = $16.07/curb mile/pass

Residential Land Use:

Size = 1000 curb miles
Average solids load before sweeping = 587 lb/curb mile
Solids accumulation rate in lb/curb mile/day = (-0.0667 x current solids load) + 44.31 lb/curb mile/day
Sweeper efficiency = 20.7%

Commercial Land Use:

Size = 100 curb miles
Average solids load before sweeping = 170 lb/curb mile
Solids accumulation rate in lb/curb mile/day = (-0.0667 x current solids load) + 41.29 lb/curb mile/day
Sweeper efficiency = 4.0%

Industrial Land Use:

Size = 200 curb miles
Average solids load before sweeping = 2100 lb/curb mile
Solids accumulation rate in lb/curb mile/day = (-0.0667 x current solids load) + 212.81 lb/curb mile/day
Sweeper efficiency = 16%

TABLE 2 (Cont'd)

City of San Jose

Sweeping cost = $14.00/curb mile

Residential Land Use:

Size = 1770 curb miles
Average solids load before sweeping = 489 lb/curb mile
Solids accumulation rate in lb/curb mile/day = (-0.0278 x current solids load) + 30.56 lb/curb mile/day
Sweeper efficiency = 36.5%

Commercial Land Use:

Size = 324 curb miles
Average solids load before sweeping = 758 lb/curb mile
Solids accumulation rate in lb/curb mile/day = (-0.0141 x current solids load) + 24.47 lb/curb mile/day

Sweeper efficiency = 32.3%

Industrial Land Use:

Size = 130 curb miles
Average solids load before sweeping = 627 lb/curb mile
Solids accumulation rate in lb/curb mile/day = (-0.0039 x current solids load) + 15.32 lb/curb mile/day
Sweeper efficiency = 36.0%

NOTE: The sweeper efficiencies and solids accumulation rates for the five areas were not reported with regard to the presence or absence of parking restrictions or parked vehicles.

load and eff is the street sweeper efficiency given in Table 2. Rain events above the 0.2 in./day threshold wash off street solids according to the following formula:

$$SR = SL \times e^{-3.91 \times RF}$$

where SL and SR are the solids load on the street surface before and after the day's rain and RF is the rainfall for the day in in./day (J.B. Gilbert & Assoc., 1978).

C. RESULTS AND DISCUSSION

The unit costs output by the solids washoff model are only as reliable as the input data used. Unfortunately, even if absolutely accurate input data were available, it would be subject to variation seasonally, over the long term as equipment changes, and across constituent zones within the area modeled. The very definition of the objective value--solids forgone--defies verification since a quantity that doesn't appear cannot be measured directly. The real value of the model output is its discrimination between the relative costs of alternative programs.

Two important and related questions are addressed by the solids washoff model. Which land use zones within an area should be swept first to prevent the most solids from washing off per dollar spent? Similarly, within a land use zone, which seasons are most important to sweep frequently to maximize solids washoff forgone per budget dollar? Figures 2 through 20 are graphs of unit cost versus sweep frequency for some of the locations and seasons examined, illustrating the influence of an area's characteristics on alternative program costs.

Seasonal Effects

Figures 2 through 4 plot the unit cost differences between land uses in North Alameda County for each season--September and October, November through March, and April through August. The unit costs associated with each land use occupy the same relative position to each other regardless of the season of interest. This is because the between-land use differences in North Alameda County arise through dissimilar solids accumulation rates and sweep efficiencies for each land use (Table 2). There are no seasonal phenomena that affect one land use differently than another. In South Alameda County the same sweep efficiency and solids accumulation rate for all three land uses was provided by Alameda County Flood Control and Water Conservation District. Thus the relationship between unit cost of preventing solids from washing off and sweep frequency for all land uses can be represented by one line on Figure 5 and varies only from one season to another.

Seasonally disaggregated plots such as Figure 5 can be used to assess how similar the chosen seasons are to one another with respect to the cost-effectiveness of a sweeping program. For South Alameda County the September and October and November through March plots are nearly coincident. They are both much lower than the summer season plot, however. This is because in the summer there are far fewer rains to wash off unswept solids than in the rainy seasons (Table 1). Since the solids accumulation rate

Unit cost of preventing solids from washing off versus sweep frequency
September and October, North Alameda County

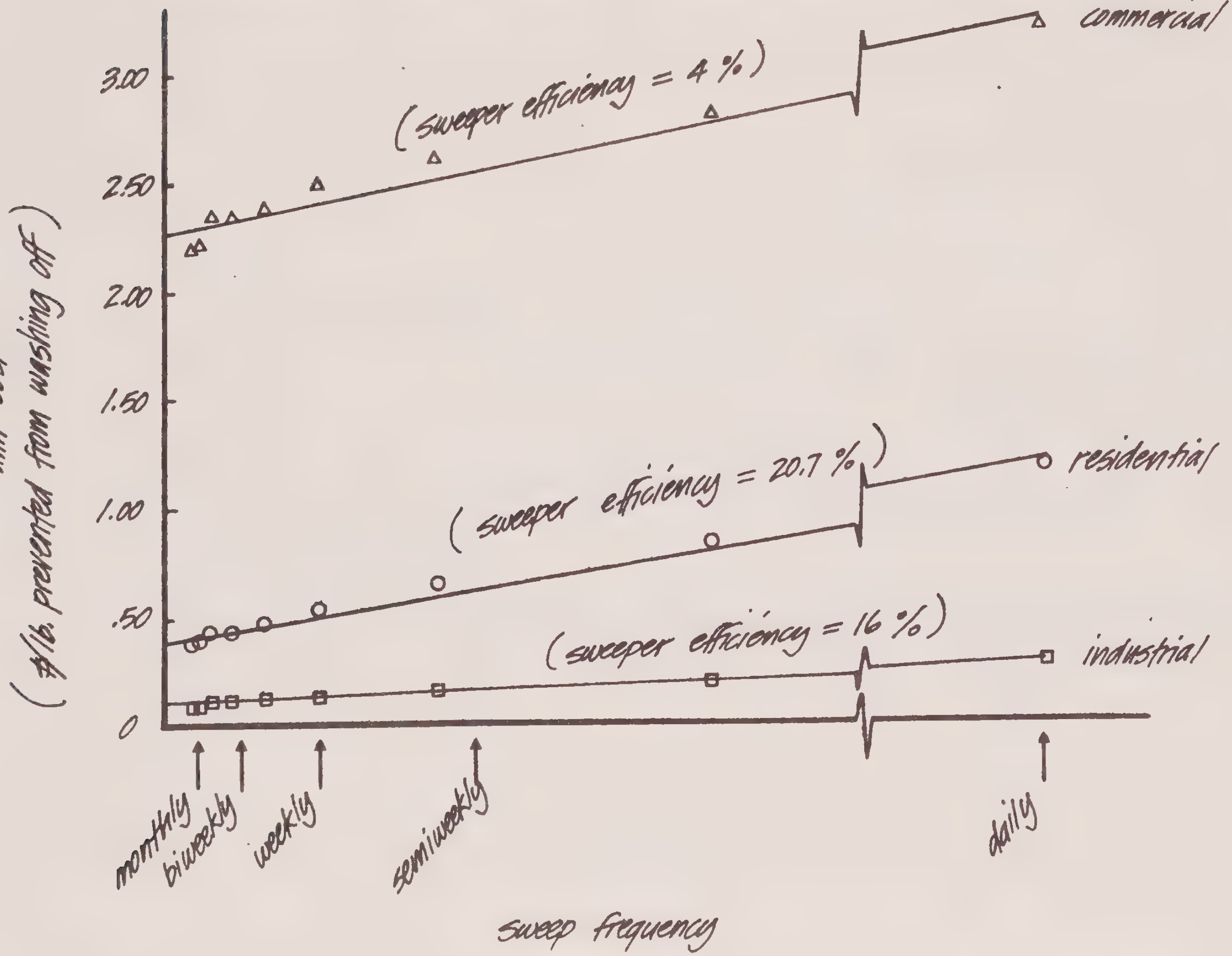


Figure 2

Unit cost of preventing solids from washing off versus sweep frequency
November through March, North Alameda County

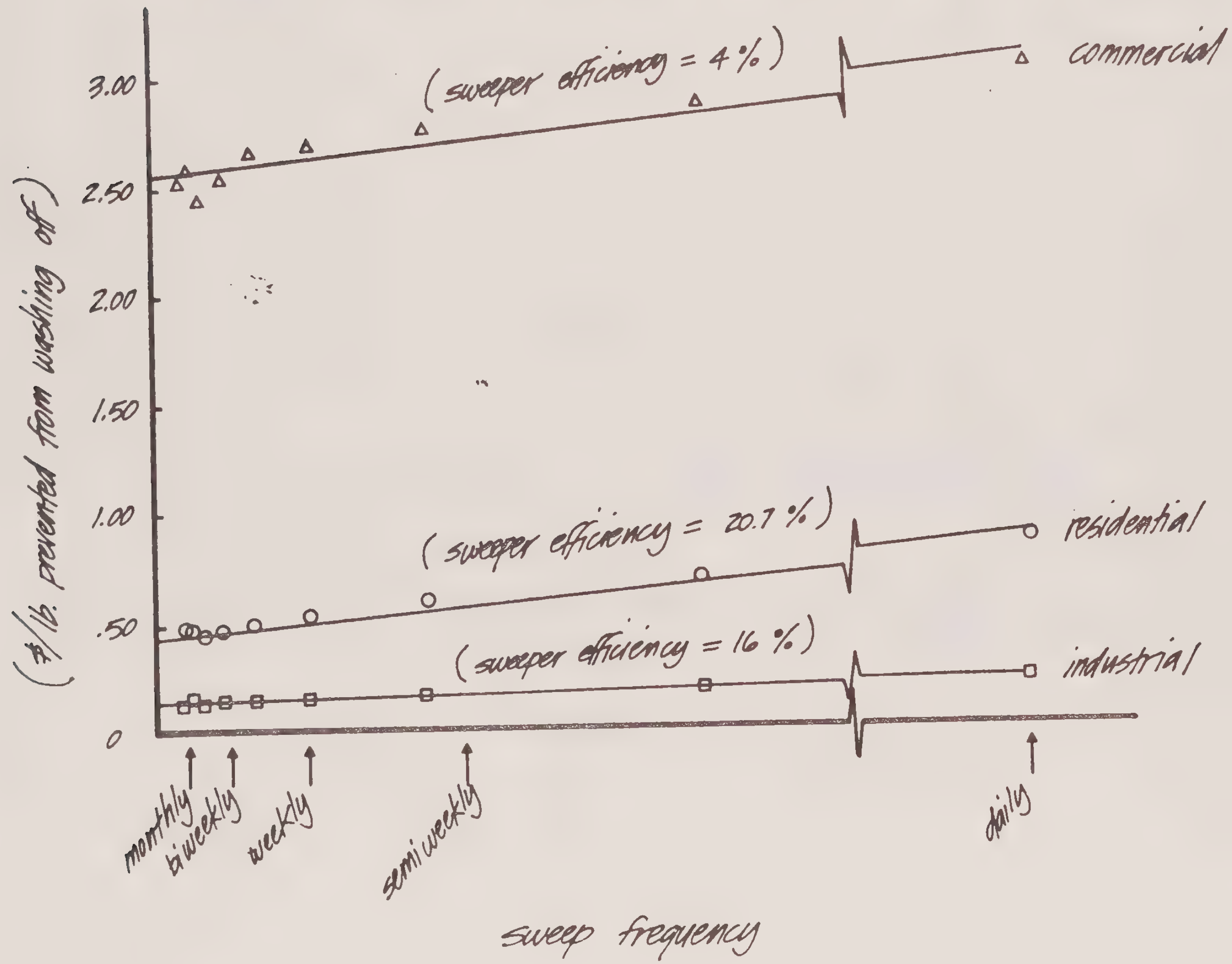


Figure 3

Unit cost of preventing solids from washing off versus sweep frequency
April through August, North Alameda County

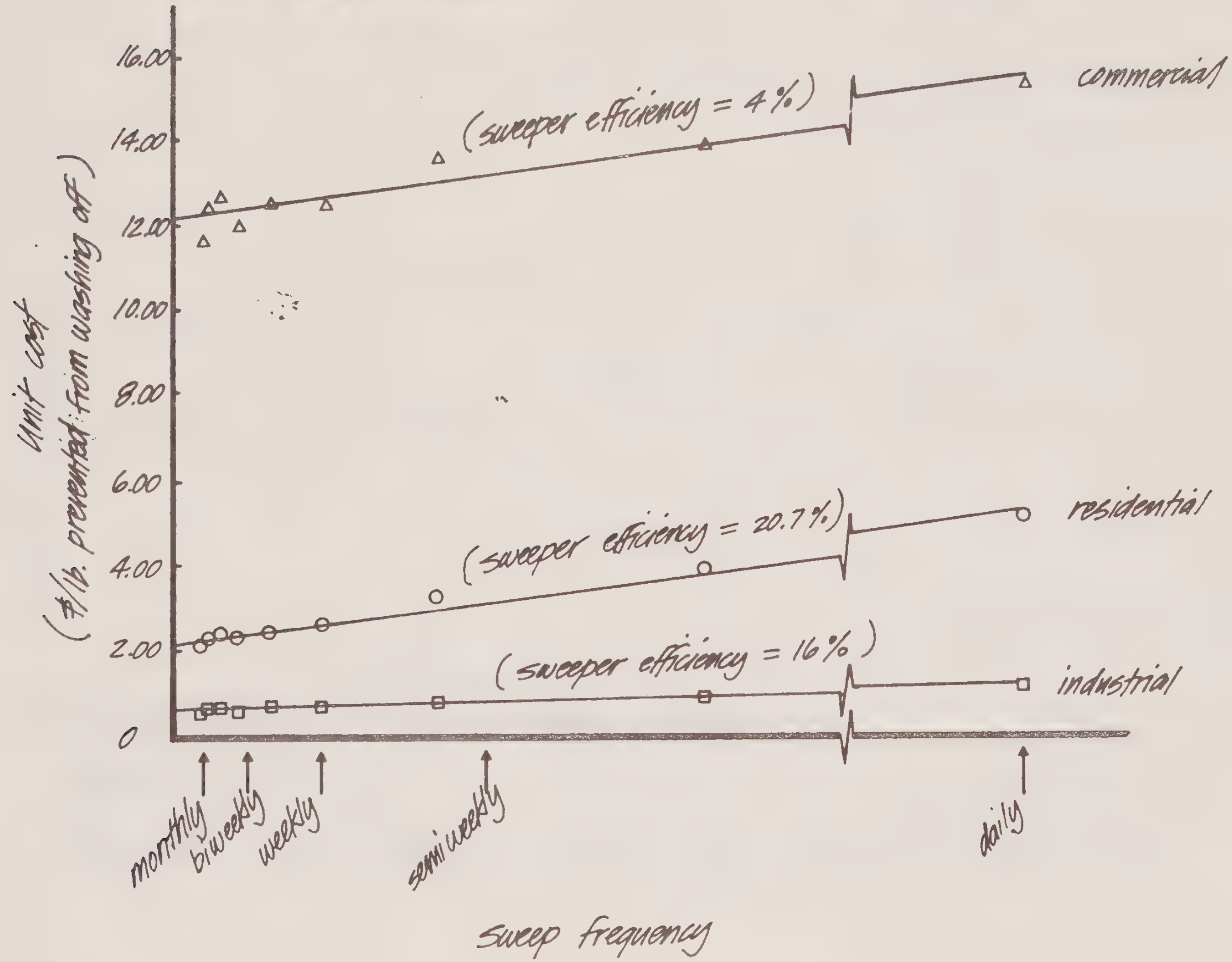
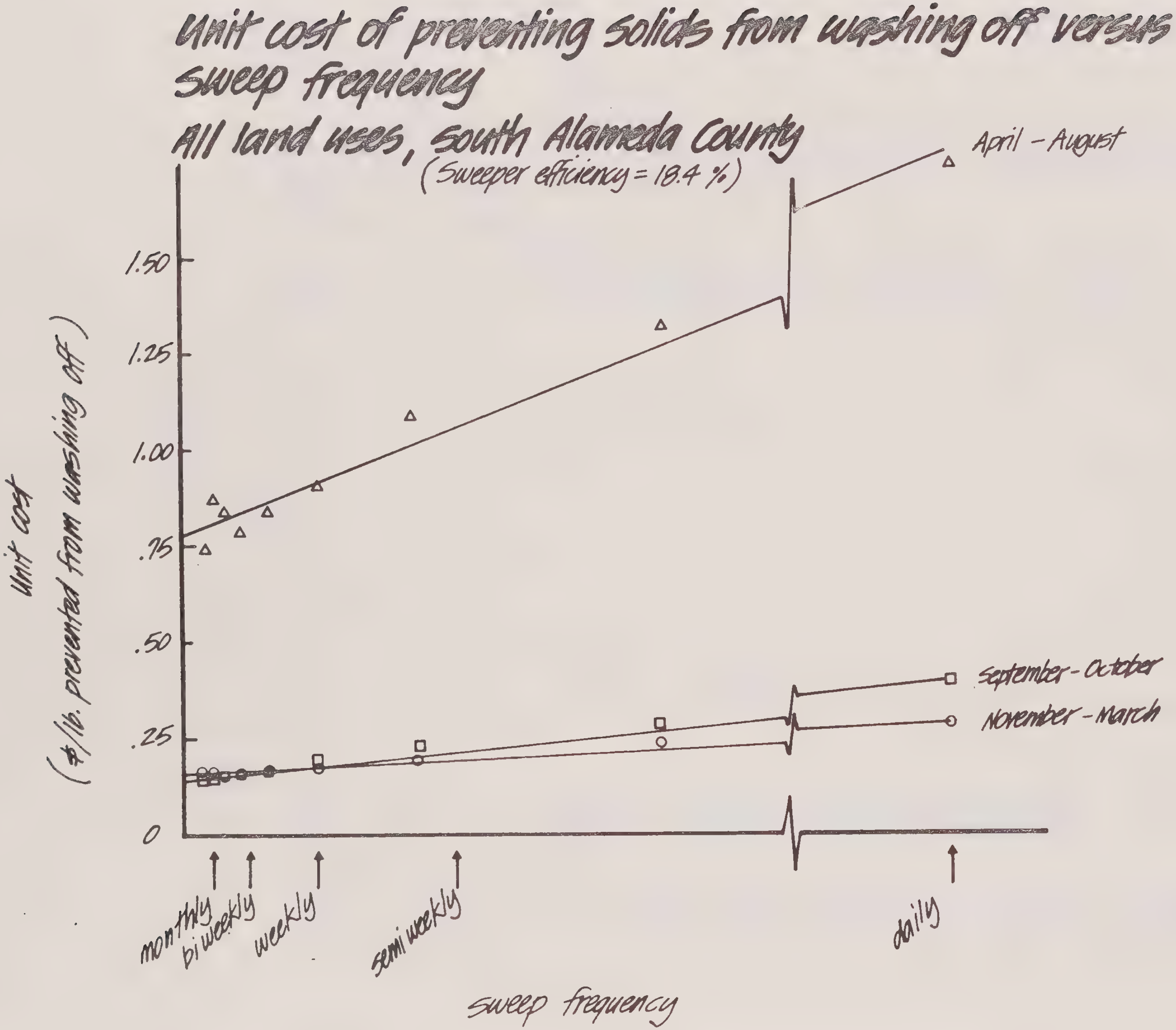


Figure 4



Unit cost of preventing solids from washing off versus sweep frequency
All land uses, South Alameda County
(Sweeper efficiency = 18.4 %)
Unit cost
($/lb. prevented from washing off)
1.50
1.25
1.00
.75
.50
.25
0
April - August
September - October
November - March
monthly
biweekly
weekly
semiweekly
daily
sweep frequency

Figure 5

Unit cost of preventing solids from washing off versus sweep frequency

Residential land use, North Alameda County (sweep efficiency = 20.7%)

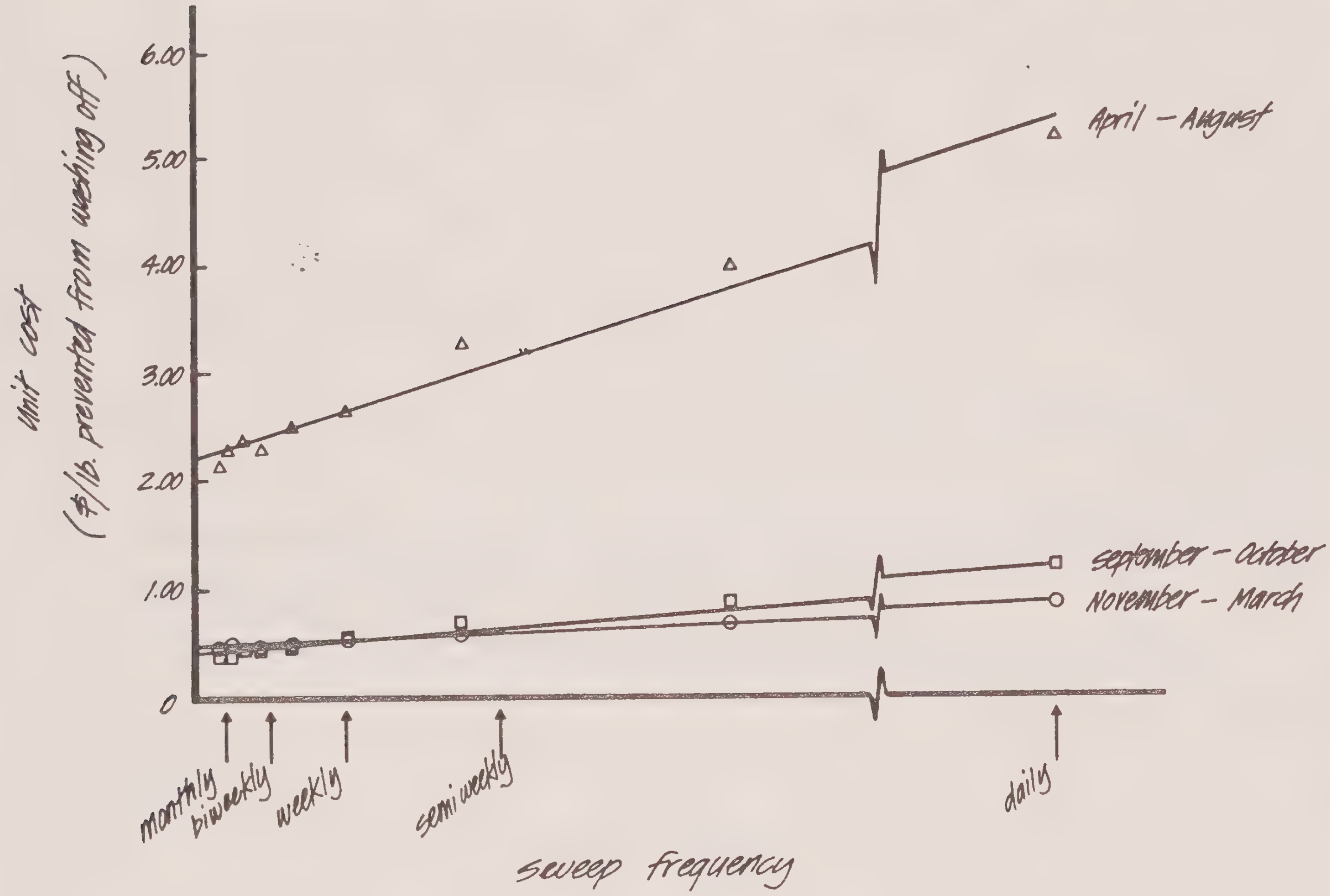


Figure 6

Unit cost of preventing solids from washing off versus sweep frequency
commercial land use, North Alameda County (sweeper efficiency = 4 %)

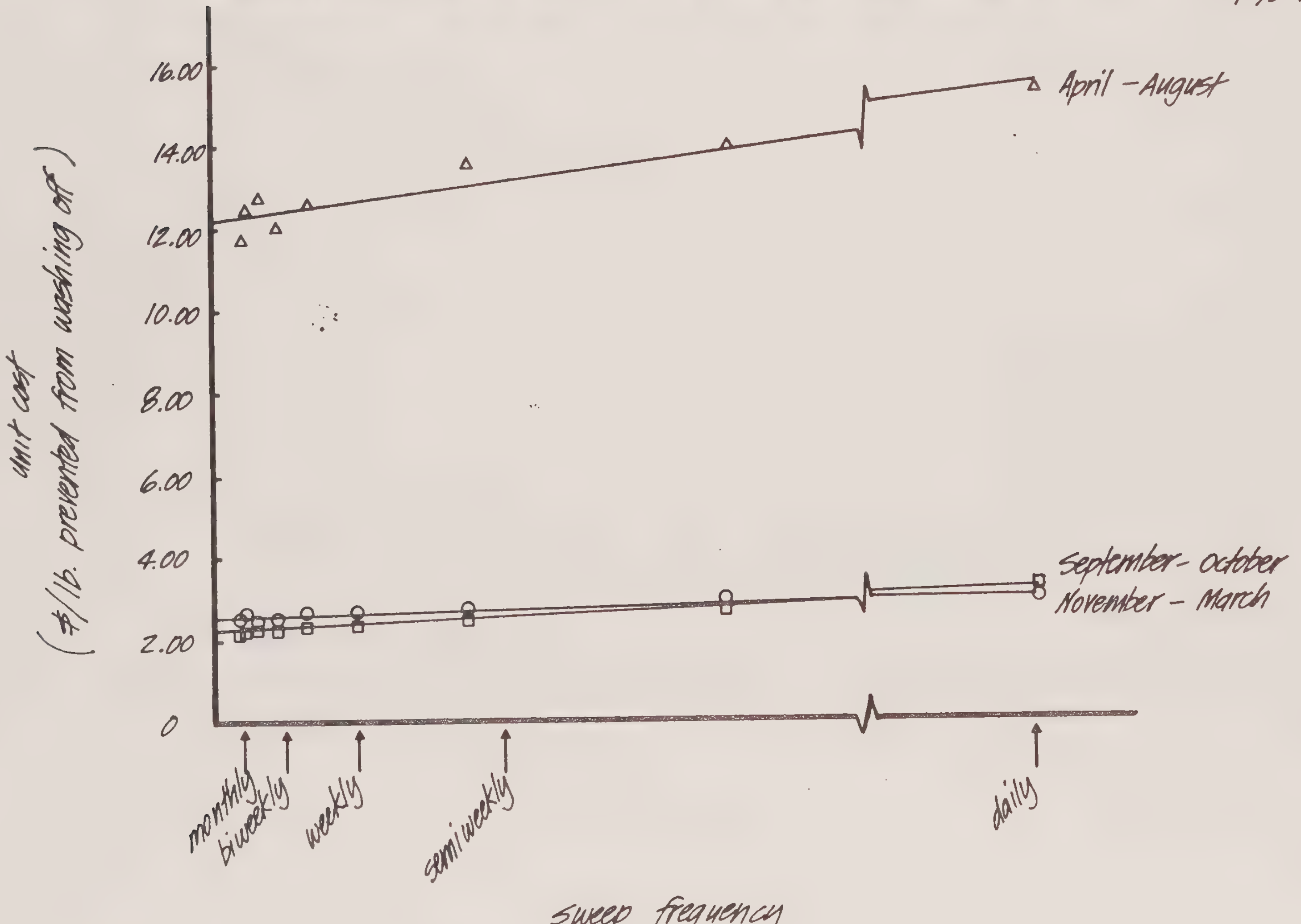


Figure 7

unit cost of preventing solids from washing off versus sweep frequency
Industrial land use, North Alameda County (sweeper efficiency = 16 %)

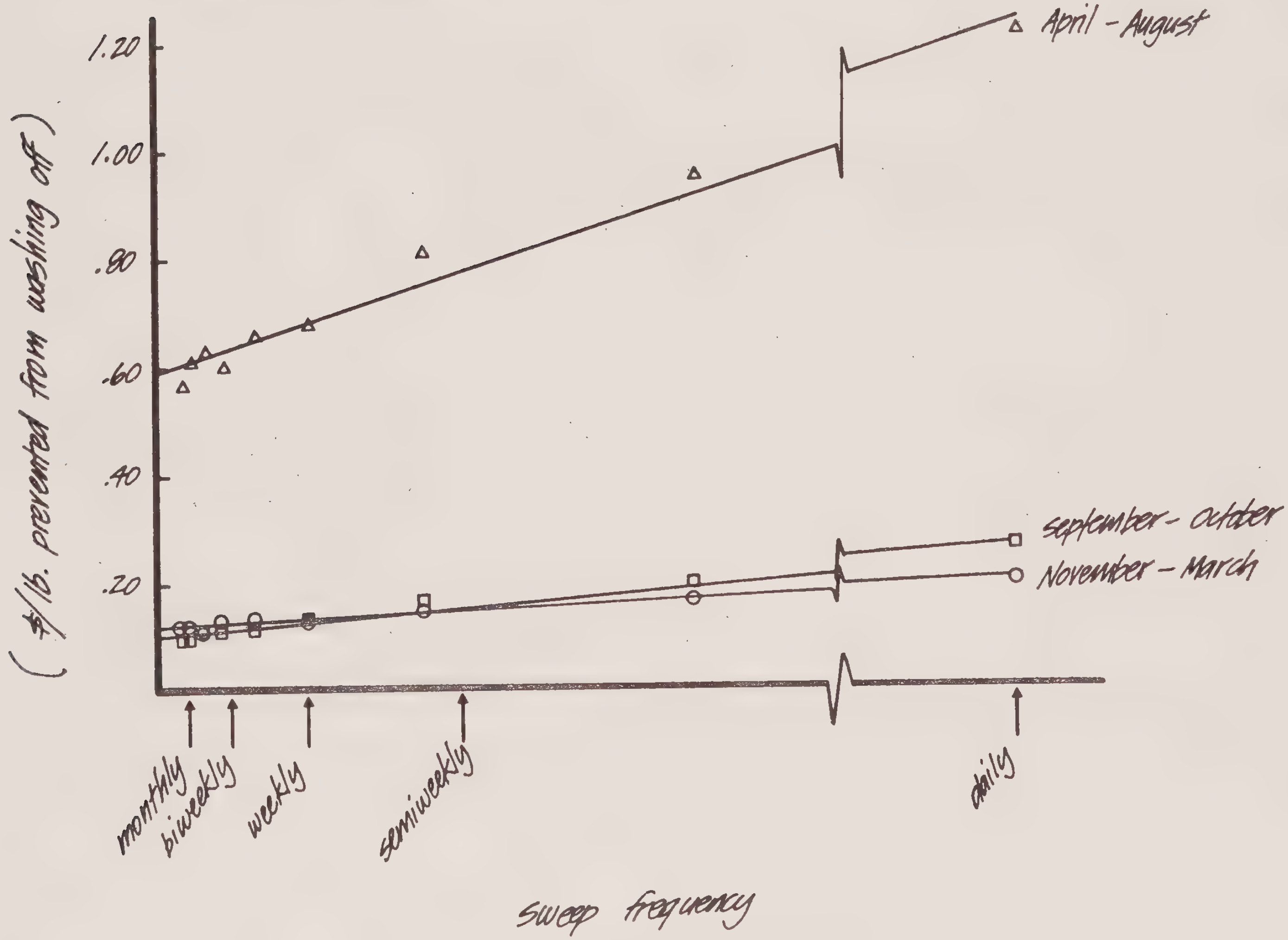
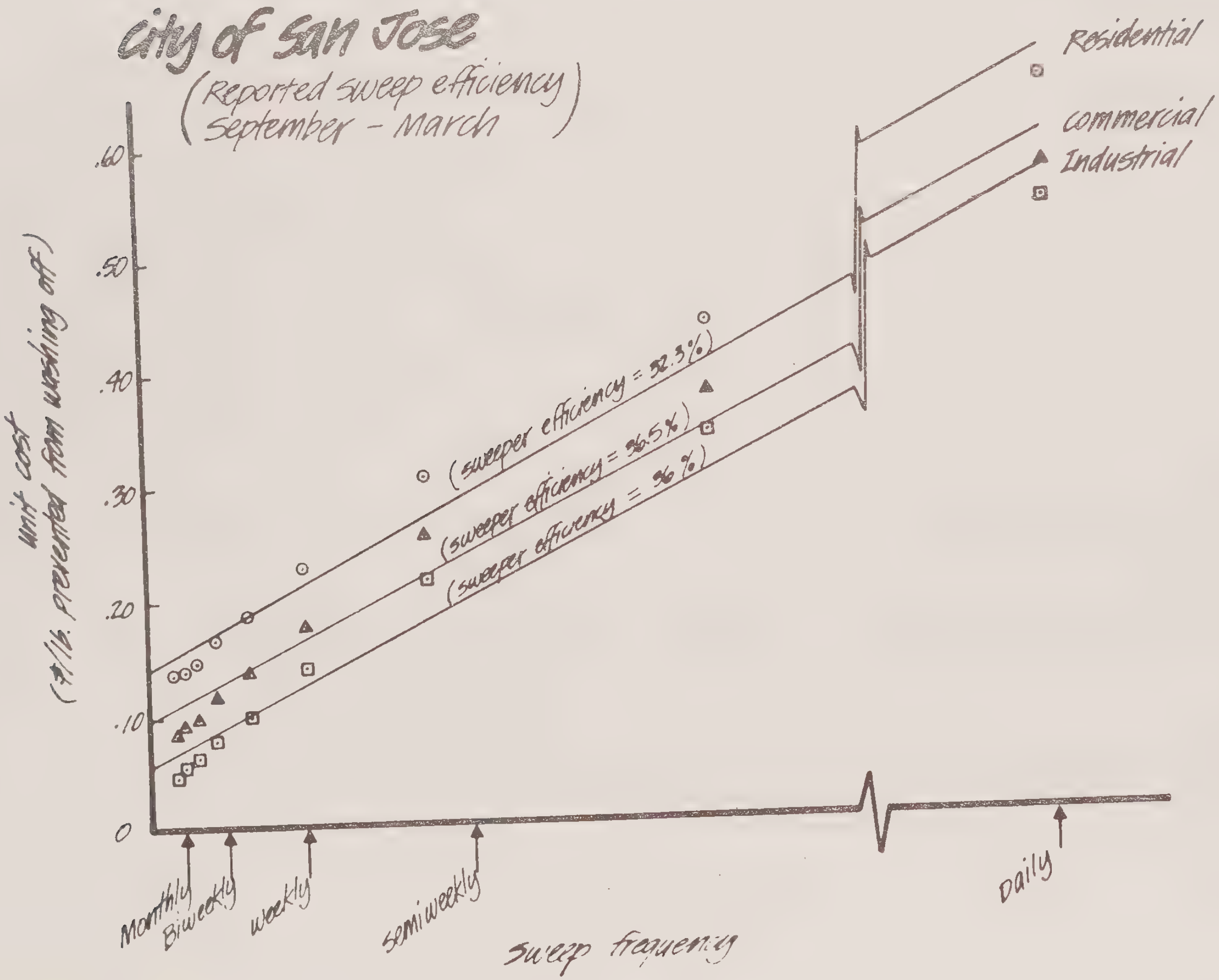


Figure 8

Figure 9

Unit cost of preventing solids from washing off versus sweep frequency



Unit cost of preventing solids from washing off versus sweep frequency

City of San Jose (Reported sweep efficiency April - August)

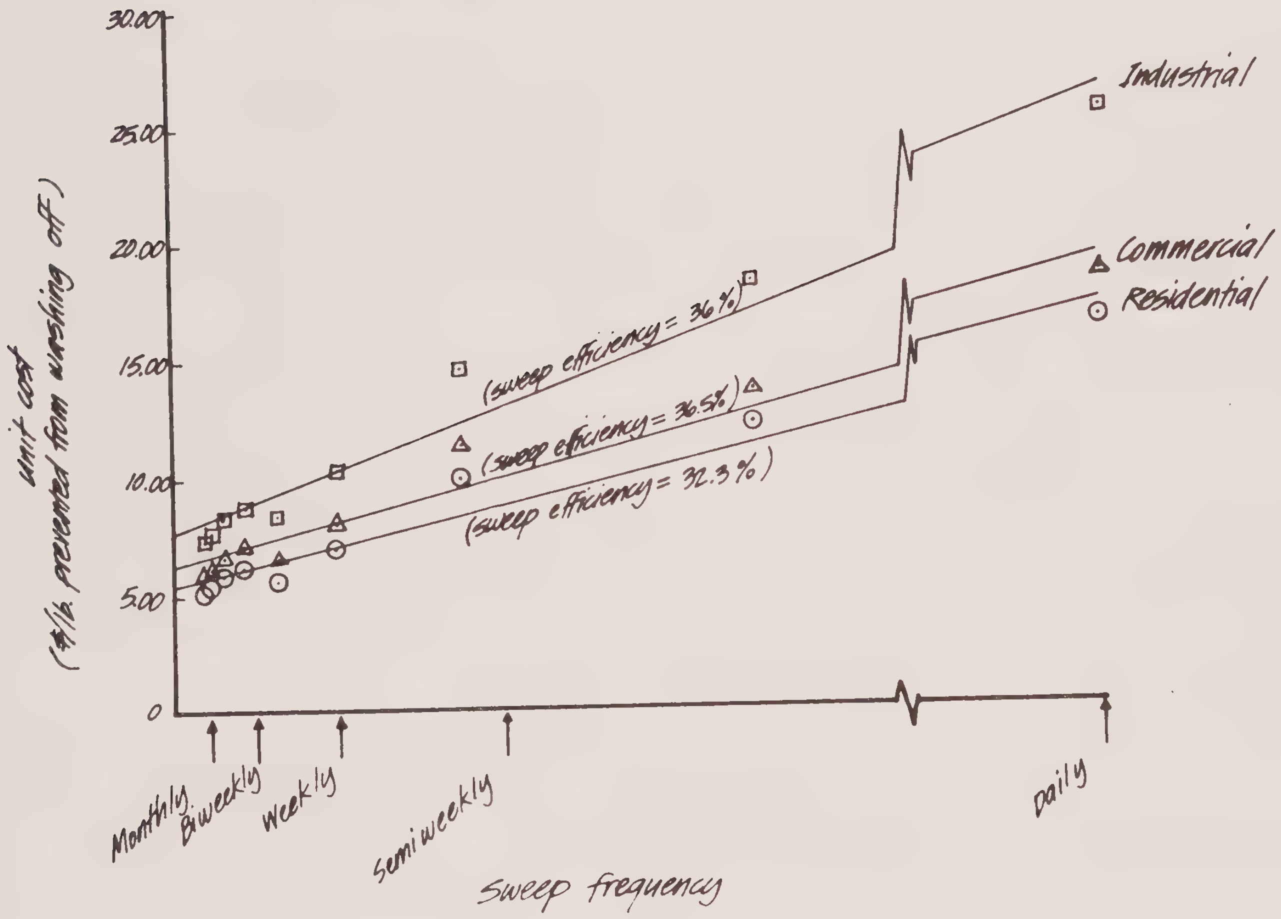


Figure 10

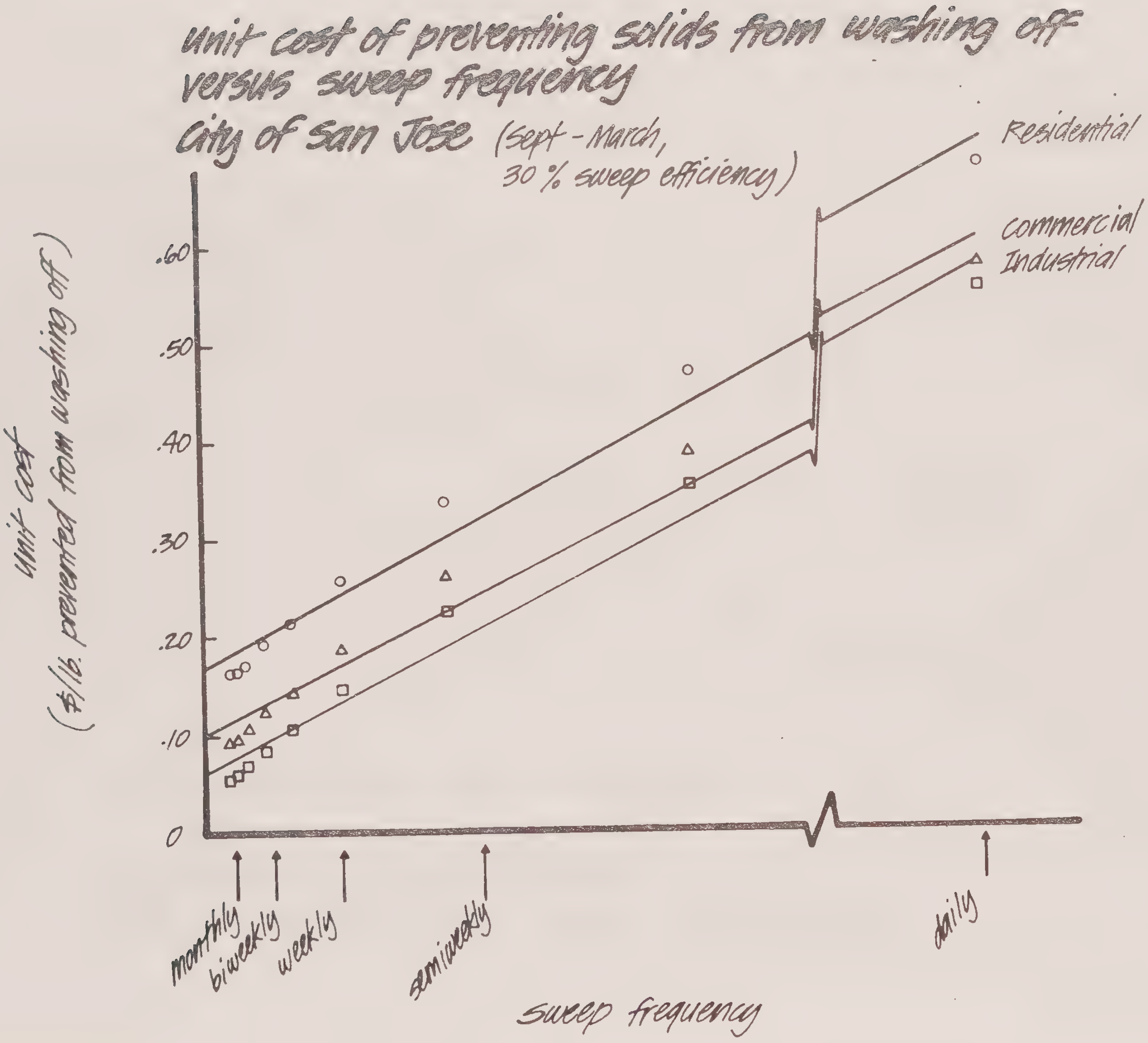

unit cost of preventing solids from washing off
versus sweep frequency
City of San Jose (Sept-March,
30 % sweep efficiency)
Residential
commercial
Industrial
unit cost
($/lb. prevented from washing off)
0
.10
.20
.30
.40
.50
.60
monthly
biweekly
weekly
semiweekly
daily
sweep frequency

Figure 11

Unit cost of preventing solids from washing off versus sweep frequency
City of San Jose (April – August, 30 % sweeper efficiency)

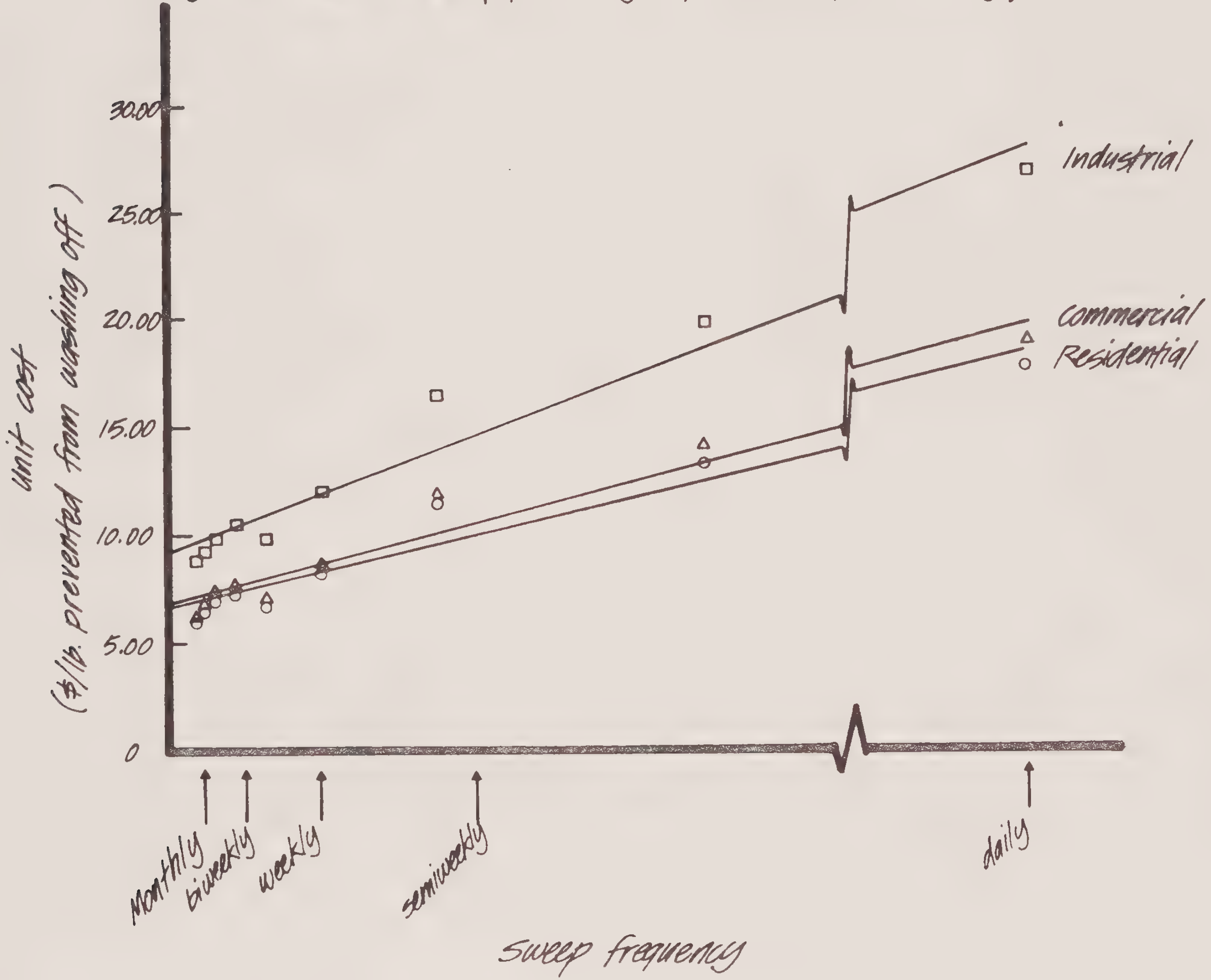


Figure 12

Unit cost of preventing solids from washing off versus sweep frequency

City of San Jose (September - March, 20 % sweep efficiency)

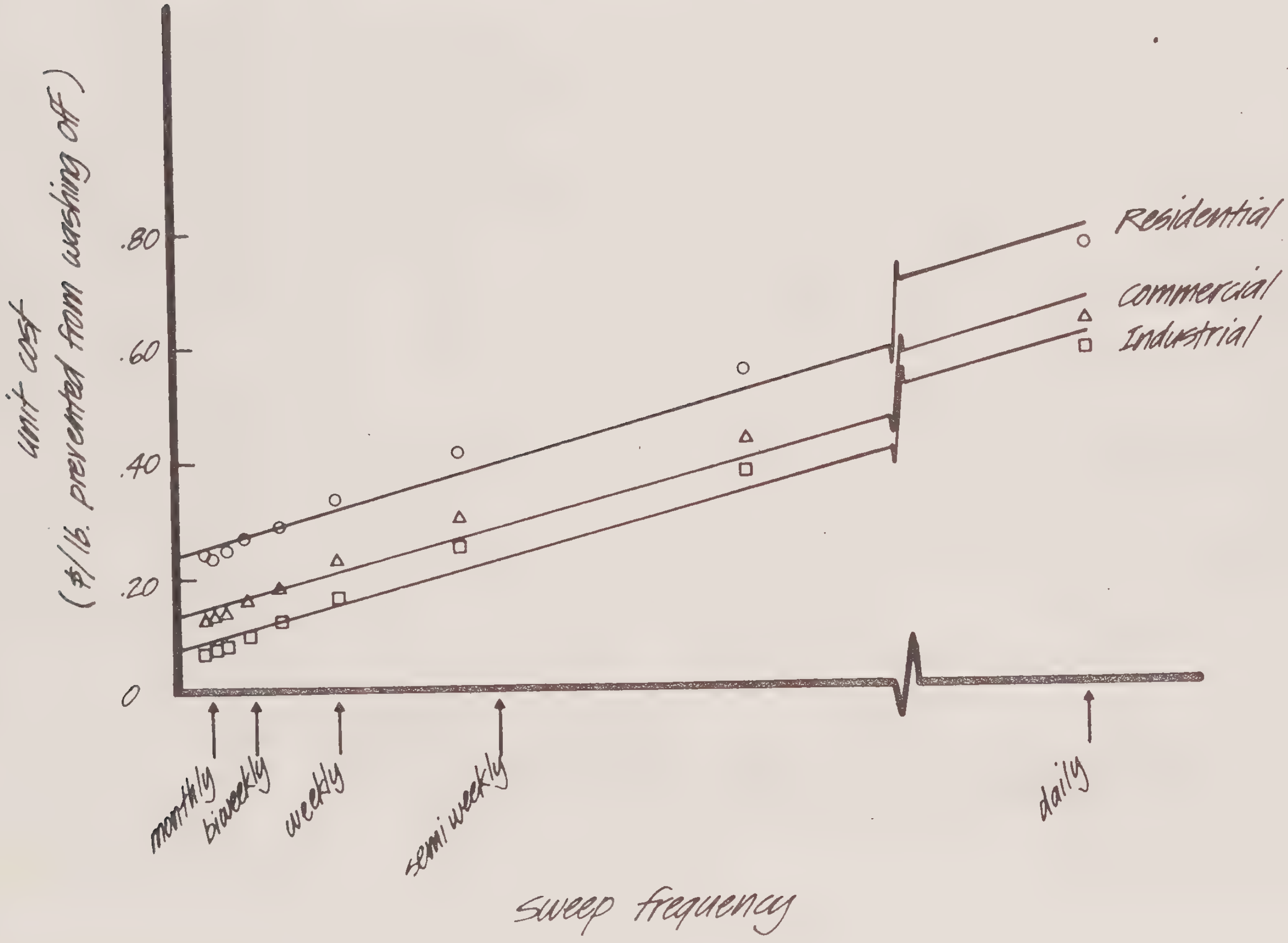


Figure 13

Unit cost of preventing solids from wash off versus sweep frequency City of San Jose (April-August, 20% sweep efficiency)

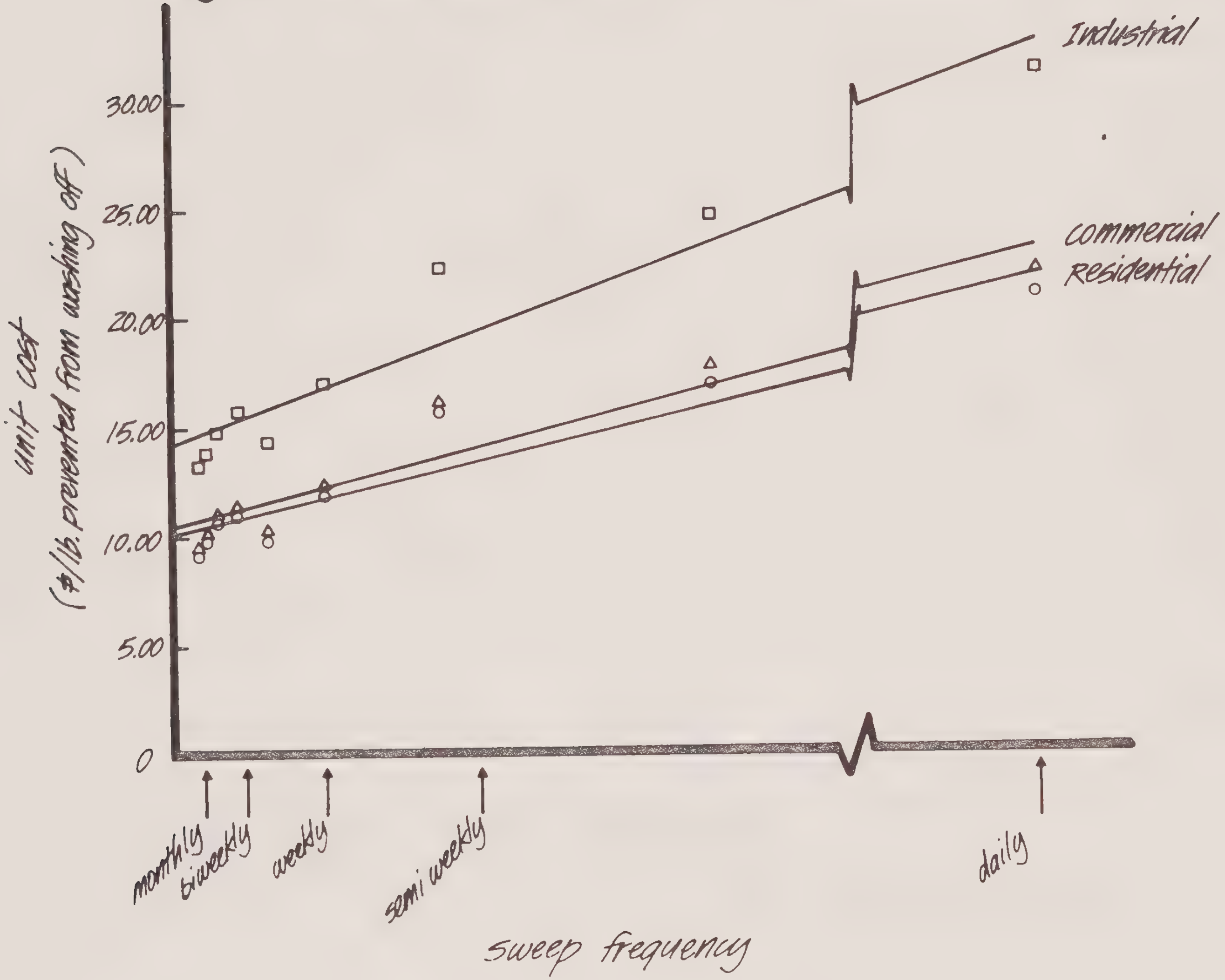


Figure 14

Unit cost of preventing solids from washing off versus sweep frequency

City of San Jose (September–March, Residential)

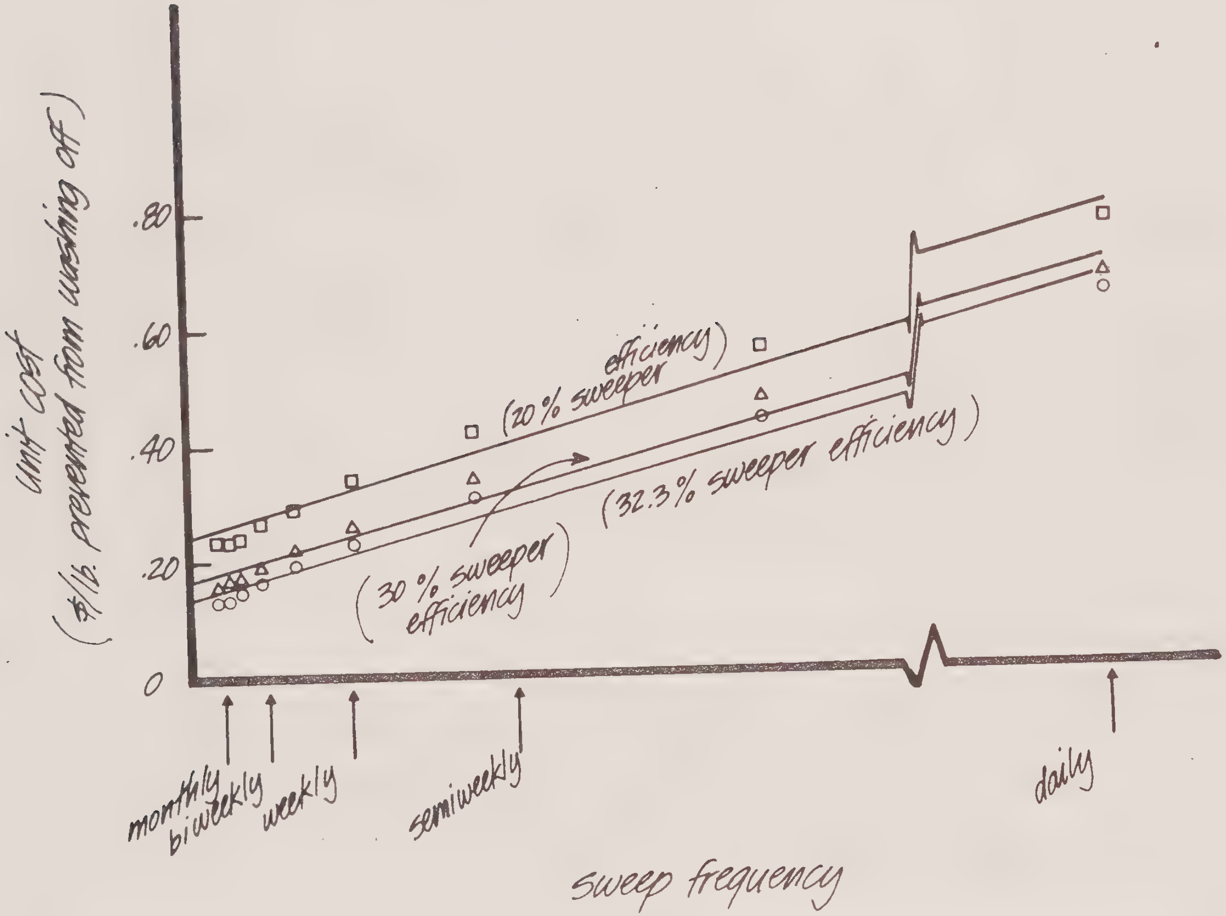


Figure 15

unit cost of preventing solids from washing off versus sweep frequency

city of San Jose (April-August, Residential)

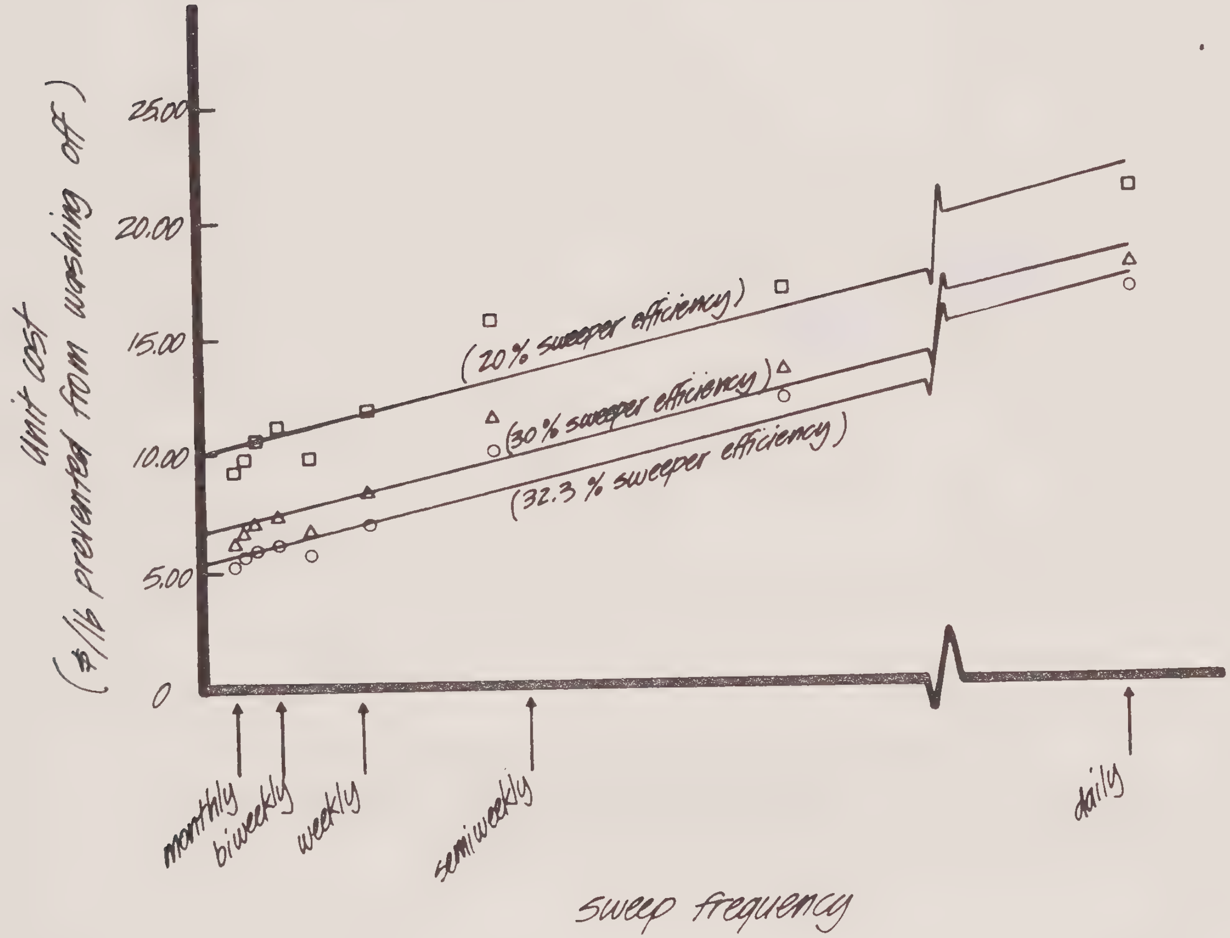
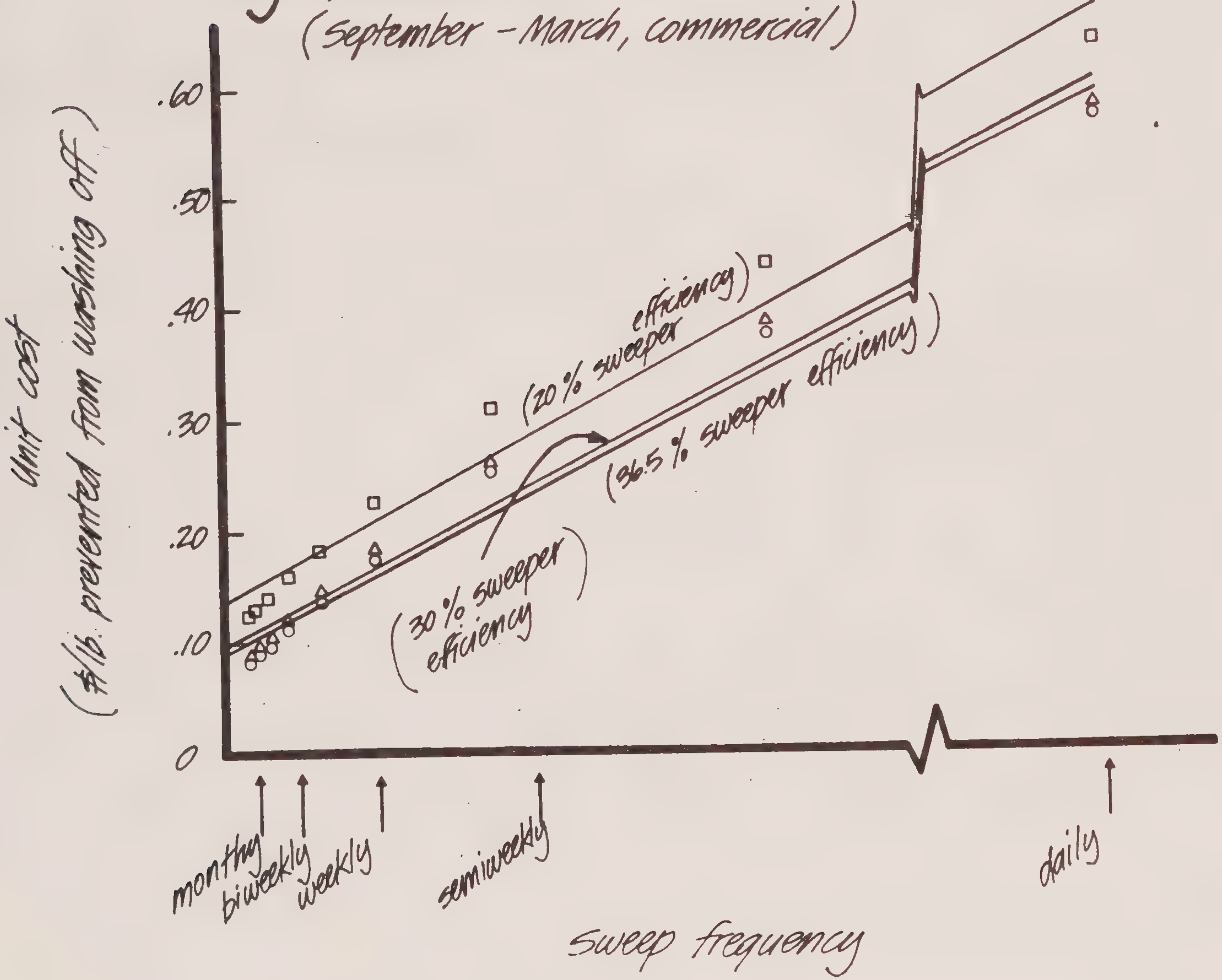


Figure 16

Figure 17

Unit cost of preventing solids from washing off versus sweep frequency

City of San Jose



Unit cost of preventing solids from washing off versus sweep frequency

City of San Jose (April - August, commercial)

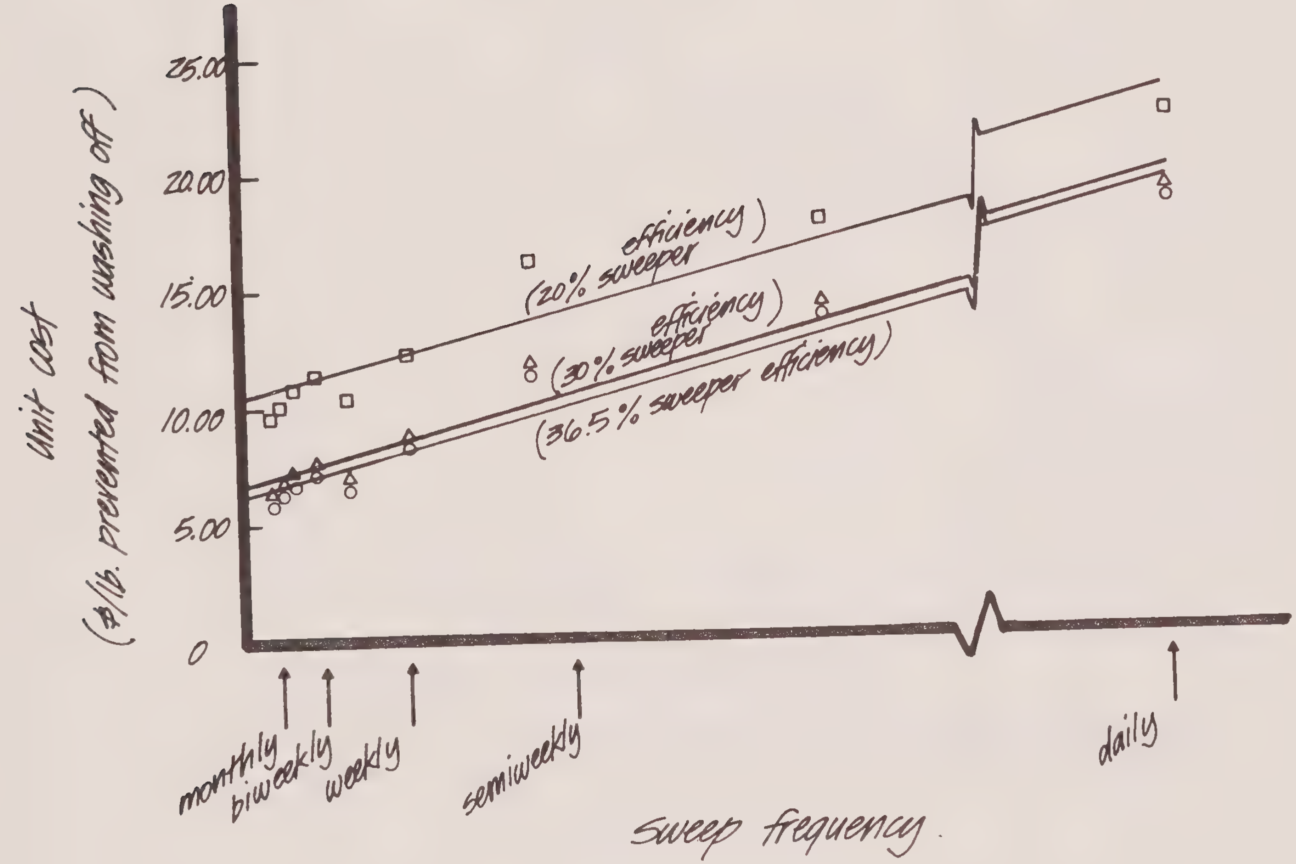


Figure 18

unit cost of preventing solids from washing off versus sweep frequency

City of San Jose (September-March, Industrial)

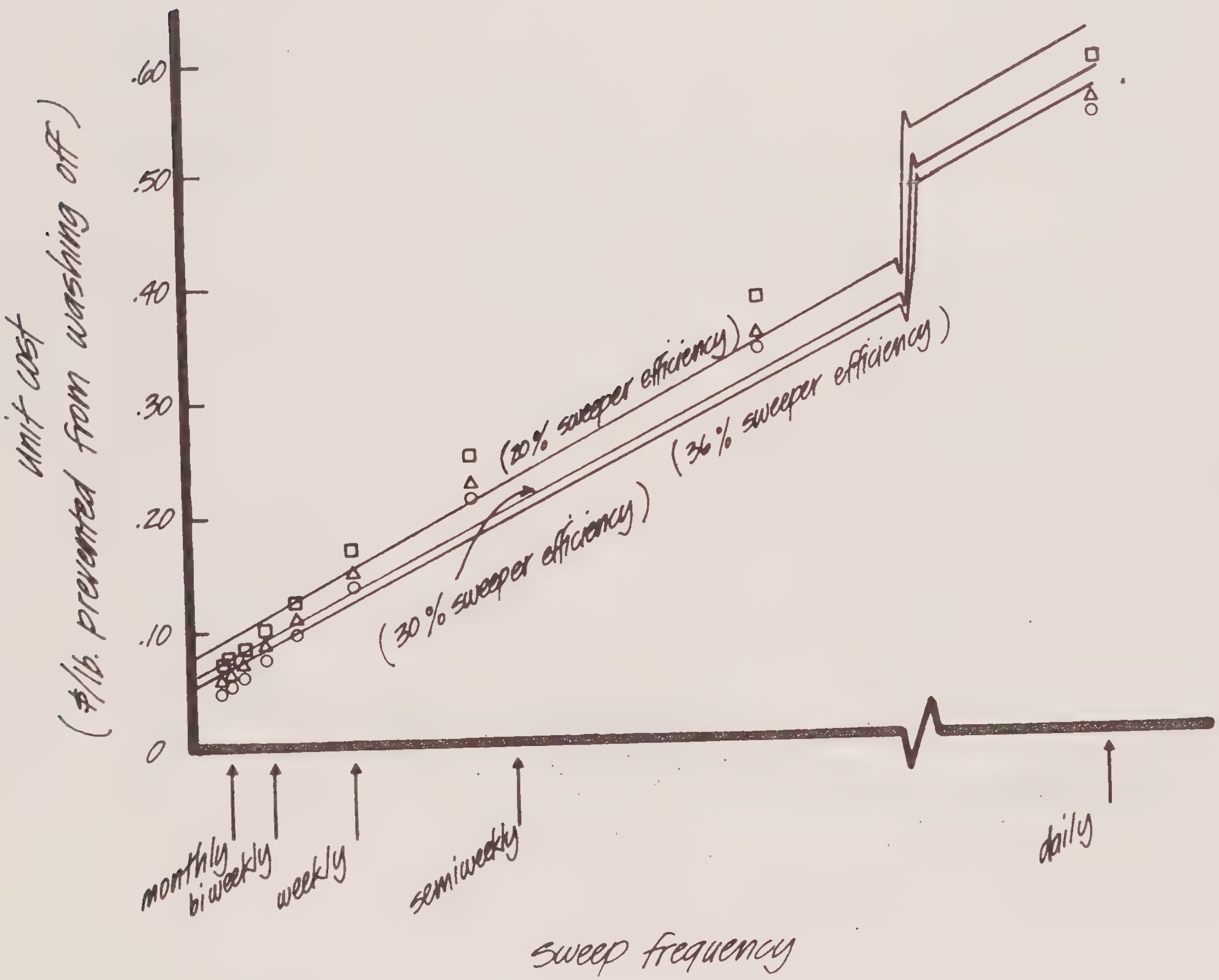
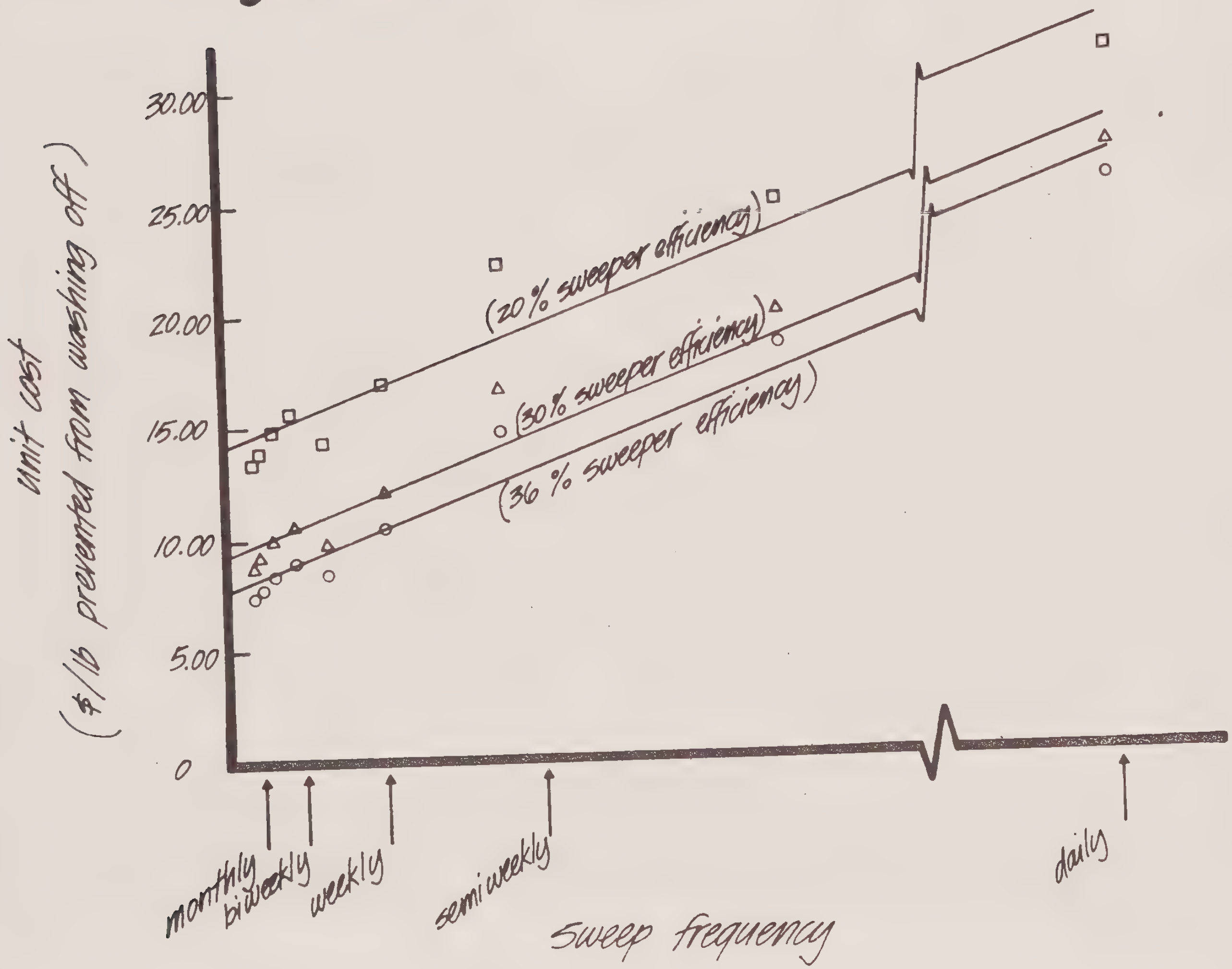


Figure 19

Figure 20

Unit cost of preventing solids from washing off versus sweep frequency

City of San Jose (April-August, Industrial)



decreases as the load of solids on the street increases, a point is reached beyond which the non-washoff solids removal mechanisms exactly offset the solids deposition mechanisms. Further time extension without sweeping does not increase the amount of solids on the street and, unless there is a significant rain, no washoff occurs. Thus, only in the winter when frequent rains can result in greater solids washoff does repeated sweeping reap corresponding reductions in street solids reaching surface waters. Figures 6 through 8 show that for each of the North Alameda County land uses, the two rain seasons nearly coincide in their unit cost versus sweep frequency relationship and solids washoff forgone during the dry season is considerably more expensive.

Administratively a two season sweeping program would be easier to manage than one which specifies three or more seasons, each with its own sweep schedule. On the basis of the Alameda County analyses, the September and October season should not be distinct from that of November through March yet these are both quite dissimilar from the dry April through August season. Two seasons--one wet and one dry--appear to adequately accommodate the sweep scheduling requirements of the entire water year in the areas studied. It is probable that two seasons would be sufficient as well for other locales of the San Francisco Bay Area. The essential feature of this two-season annual scheduling is that frequent wet season sweeping begin prior to the first significant rain in the fall and continue for the duration of the wet season. Much less frequent sweeping is indicated in the dry season from a water quality perspective. Although September through March and April through August correspond approximately with the wet and dry seasons in these areas, other areas must examine their precipitation records to determine the scheduling most appropriate for their needs.

The two season rather than three season model was used in the San Jose analysis. So few significant rains occurred during the dry season that the unit cost of solids washoff forgone became prohibitive--$5 or more per pound of solids prevented from washing off. Figures 9 and 10 show the September-March and April-August unit cost versus sweep frequency relationships for San Jose. The differences between land uses are much less for San Jose than for North Alameda County (Figures 2 through 4). This reflects more similar sweep efficiencies and solids accumulation rates in San Jose than in Alameda County. The differences in the unit cost versus sweep frequency curves between land uses in a given area are attributable to two sources. First, the solids accumulation rate functions may differ between land uses (Table 2). The higher the solids accumulation rate, the lower will be the unit cost of preventing solids from washing off. Second, the sweeper efficiency may differ between land uses (Table 2). As an example, the influence that a change in sweeper efficiency would have on the unit cost of preventing solids from washing off in San Jose is estimated below.

Sweeper Efficiency

To assess the importance of sweeper efficiency on unit cost, the two-season San Jose model was run again using 30% and 20% sweeper efficiencies. All other input parameters were left unchanged. The results of these runs

for each of the two seasons are shown on Figures 11 and 12 for 30% efficiency and Figures 13 and 14 for 20% efficiency. The unit cost versus sweep frequency plots for residential, commercial, and industrial land uses for both seasons in San Jose are given on Figures 15 through 20. The unit cost increases as sweep efficiency decreases but no change in the relative economy of preventing solids from washing off between the three land uses occurs.

Optimizing a Program

The results of these analyses can be used to design a sweeping program for these areas that is economically optimized toward the water quality objective. By successively selecting sweeping program elements in an increasing order of unit cost until the desired amount of solids washoff forbearance is obtained or available funds are exhausted, the most cost-effective (in terms of water quality) program is derived. Tables 3 through 7 list the programs for each of the five areas in order of increasing effort and increasing unit cost of solids washoff prevented. Sweeping program elements are introduced one at a time and are defined by season, land use, and sweep frequency. For example, on Table 3 the lowest unit cost program would be to sweep industrial areas monthly during the September and October season. That is, if the street sweeping budget is very limited, all of the industrial streets in North Alameda County (Alameda, Oakland, and San Leandro) should be swept monthly during this season at a total cost of about $9000 and prevent 80,000 pounds of street solids from washing off the street. This unit cost ratio is $.11 per pound prevented from washing off. The next level of effort would be to sweep those same industrial areas biweekly instead of monthly at a cost of $19,000 to forego 155,000 pounds washoff. The third level of effort sweeps industrial street biweekly during September and October and monthly from November through March. The total cost of this program would be $37,000 for preventing over 300,000 pounds of street solids from washing off. No land uses and seasons having blank entries on the table are swept under a given alternative.

Another way to use the tables is to pick off the best program for a given budget. In North Alameda County (Table 3), if $1 million are available, maximum watercourse protection could be had by sweeping industrial areas daily September through March, residential areas biweekly during September and October and weekly from November through March (alternative 13). Commercial areas are not swept and no areas are swept during the dry season. At the bottom of Table 3 is the performance of the current street sweeping program in North Alameda County. Since considerations other than water quality dictated the program elements, it is not surprising that it has a much higher unit cost of solids prevented from washing off than does the comparable levels of effort identified by the solids washoff model. For example, the current cost of street sweeping in North Alameda County is $1.1 million dollars and 1.79 million pounds of solids washoff is forgone. For the same budget, alternative 14 prevents about twice as much solids from washing off. Alameda County sweeping programs currently emphasize

Alternative	Season									Total Washoff Prevented (1000s lb/yr)	Total Cost (1000s $/year)	Unit Cost ($/lb)
	Nov. - Mar.			Apr. - Aug.			Sept. - Oct.					
	Res.	Com.	Ind.	Res.	Com.	Ind.	Res.	Com.	Ind.			
1									M	80	9	.11
2									B	155	19	.12
3			M						B	302	37	.12
4			B						B	456	57	.12
5			W						B	702	93	.13
6			W						W	806	110	.14
7			D						W	2080	406	.20
8			D						D	2490	550	.22
9			D				M		D	2590	595	.23
10			D				B		D	2690	643	.24
11	M		D				B		D	2890	735	.25
12	B		D				B		D	3090	835	.27
13	W		D				B		D	3420	1020	.30
14	W		D				W		D	3550	1100	.31
15	W		D			M	W		D	3580	1120	.31
16	W		D			B	W		D	3620	1150	.32
17	W		D			W	W		D	3680	1190	.32
18	D		D			W	W		D	5170	2680	.52
19	D		D			W	D		D	5610	3400	.61
20	D		D			D	D		D	5860	3770	.64
21	D		D			D	D	M	D	5860	3770	.64
22	D		D	M		D	D	M	D	5900	3880	.66
23	D		D	M		D	D	B	D	5910	3890	.66
24	D		D	B		D	D	B	D	5960	4010	.67
25	D		D	B		D	D	W	D	5960	4020	.67
26	D	M	D	B		D	D	W	D	5960	4030	.68
27	D	B	D	B		D	D	W	D	5970	4040	.68
28	D	B	D	W		D	D	W	D	6040	4260	.71
29	D	W	D	W		D	D	W	D	6050	4280	.71
30	D	D	D	W		D	D	W	D	6090	4410	.72
31	D	D	D	W		D	D	D	D	6110	4480	.73
32	D	D	D	D		D	D	D	D	6380	6330	.99
33	D	D	D	D	M	D	D	D	D	6380	6340	.99
34	D	D	D	D	W	D	D	D	D	6390	6370	1.00
35	D	D	D	D	D	D	D	D	D	6400	6540	1.02
CURRENT PROGRAM										1790	1100	.61

M = monthly
B = biweekly
W = weekly
D = daily

TABLE 4

MID ALAMEDA COUNTY

Alternative	Season Nov. - Mar. All Uses	Season Apr. - Aug. All Uses	Season Sept. - Oct. All Uses	Total Washoff Prevented (1000s lb/yr)	Total Cost (1000s $/year)	Unit Cost ($/lb)
1			M	18	4	.22
2			B	35	8	.24
3	M		B	69	17	.24
4	B		B	105	25	.24
5	W		B	162	42	.26
6	W		W	185	49	.27
7	D		W	460	183	.40
8	D		D	543	247	.45
9	D	M	D	551	257	.47
10	D	B	D	560	268	.48
11	D	W	D	573	288	.50
12	D	D	D	623	453	.73
CURRENT PROGRAM				203	119	.59

M = monthly
B = biweekly
W = weekly
D = daily

TABLE 5

SOUTH ALAMEDA COUNTY

Alternative	Season			Total Washoff Prevented (1000s lb/yr)	Total Cost (1000s $/year)	Unit Cost ($/lb)
	Nov. - Mar.	Apr. - Aug.	Sept. - Oct.			
1			M	78	12	.15
2			M	229	36	.16
3	M		B	302	49	.16
4	B		B	457	75	.16
5	W		B	710	123	.17
6	W		W	808	145	.18
7	D		W	2010	538	.27
8	D		D	2370	726	.31
9	D	M	D	2410	755	.31
10	D	B	D	2440	787	.32
11	D	W	D	2500	847	.39
12	D	D	D	2720	1330	.49
CURRENT PROGRAM				615	159	.26

M = monthly
B = biweekly
W = weekly
D = daily

TABLE 6

CITY OF OAKLAND

Alternative	Season									Total Washoff Prevented (1000s lb/yr)	Total Cost (1000s $/year)	Unit Cost ($/lb)
	Nov. - Mar.			Apr. - Aug.			Sept. - Oct.					
	Res.	Com.	Ind.	Res.	Com.	Ind.	Res.	Com.	Ind.			
1									M	56	7	.12
2									B	109	14	.13
3			M						B	213	28	.13
4			B						B	321	43	.13
5			W						B	495	70	.14
6			W						W	569	82	.14
7			D						W	1470	305	.21
8			D						D	1760	417	.23
9			D				M		D	1830	446	.24
10			D				B		D	1900	482	.25
11	M		D				B		D	2040	550	.27
12	B		D				B		D	2180	645	.29
13	W		D				B		D	2410	760	.32
14	W		D				W		D	2500	824	.33
15	W		D			M	W		D	2530	841	.33
16	W		D			B	W		D	2550	859	.34
17	W		D			W	W		D	2600	893	.34
18	D		D			W	W		D	3650	2000	.55
19	D		D			W	D		D	3960	2540	.64
20	D		D			D	D		D	4130	2820	.68
21	D		D			D	D	M	D	4130	2820	.68
22	D		D	M		D	D	M	D	4170	2900	.70
23	D		D	M		D	D	B	D	4170	2910	.70
24	D		D	B		D	D	B	D	4200	3000	.71
25	D		D	B		D	D	W	D	4200	3010	.72
26	D	M	D	B		D	D	W	D	4210	3010	.72
27	D	B	D	B		D	D	W	D	4210	3020	.72
28	D	B	D	W		D	D	W	D	4260	3190	.75
29	D	W	D	W		D	D	W	D	4270	3200	.75
30	D	D	D	W		D	D	W	D	4300	3320	.77
31	D	D	D	W		D	D	D	D	4320	3370	.78
32	D	D	D	D		D	D	D	D	4510	4750	1.05
33	D	D	D	D	M	D	D	D	D	4510	4760	1.06
34	D	D	D	D	W	D	D	D	D	4510	4790	1.06
35	D	D	D	D	D	D	D	D	D	4520	4920	1.09
CURRENT PROGRAM										1330	815	.63

M = monthly
B = bimonthly
W = weekly
D = daily

TABLE 7

CITY OF SAN JOSE
(REPORTED SWEEPER EFFICIENCIES)

Alternative	Season						Total Washoff Prevented (1000s lb/yr)	Total Cost (1000s $/year)	Unit Cost ($/lb)
	Sept. - Mar.			Apr. - Aug.					
	Res.	Com.	Ind.	Res.	Com.	Ind.			
1			M				168	12	.07
2			B				276	25	.09
3		M	B				544	54	.10
4		B	B				759	87	.11
5		B	W				834	111	.13
6	M	B	W				1860	271	.15
7	B	B	W				2750	448	.16
8	B	W	W				2950	509	.17
9	W	W	W				3990	842	.21
10	W	W	D				4090	1040	.25
11	W	D	D				4490	1530	.34
12	D	D	D				6750	4210	.62
13	D	D	D	M			6770	4340	.64
14	D	D	D	B			6800	4480	.66
15	D	D	D	B	M		6800	4510	.66
16	D	D	D	W	M		6830	4770	.67
17	D	D	D	W	B		6830	4800	.70
18	D	D	D	W	W		6840	4850	.71
19	D	D	D	W	W	M	6840	4860	.71
20	D	D	D	W	W	B	6840	4870	.71
21	D	D	D	W	W	W	6840	4890	.71
22	D	D	D	D	W	W	6930	7050	1.02
23	D	D	D	D	D	W	6940	7440	1.07
24	D	D	D	D	D	D	6950	7600	1.09

M = Monthly
B = Biweekly
W = Weekly
D = Daily

aesthetics and to a lesser extent traffic safety. Thus commercial sweeping is much more frequent than either industrial or residential. Alternative 14 on Table 3 recommends nearly the reverse policy, with no commercial area sweeping at all.

Like North Alameda County, the other areas studied showed that unit costs for wet season sweeping are much less than during the dry season (Tables 3 through 7). This is because during the long periods between dry season washoff events, the street solids load levels off and no benefit in solids washoff forgone will result if the streets remain unswept. During the wet season, rains are seldom far enough apart to allow unswept streets to reach the maximum solids load.

The relative order of increasing unit costs between land uses is alike for Oakland and North Alameda County but different in San Jose. The former strongly favored sweeping industrial areas as opposed to commercial areas (Tables 3 and 6). Residential area sweeping priority was intermediate. This trend mirrors the comparative loading rates and sweeping efficiencies which are high in industrial areas and low in commercial areas. In Mid and South Alameda County areas land use does not affect sweep efficiency or solids loading rate so the unit cost is the same across land use categories. Unlike the Oakland and North Alameda County cases, the relative land use priorities in San Jose changed between the wet and dry season (Table 7). During the wet season industrial land uses were most cost effective to sweep while sweeping residential land uses was least cost effective. The reverse priority held during the dry season. The reason for this phenomenon is probably that since solids accumulation rates and sweeper efficiencies are nearly the same between land uses in San Jose, the presence or absence of rainfall easily alters their net effect on the unit cost of preventing solids from washing off the streets. The important point to note is that the advantage of wet season sweeping over dry season sweeping far outweighs any between-land use differences.

Tables 8 and 9 show the program alternatives for the hypothetical 30% and 20% sweep efficiencies, respectively, depicted on Figures 11 through 14. The ranking of program elements remains essentially the same between sweep efficiencies, but the unit cost value increases with decreasing sweeper efficiency. Obviously deterioration of sweeping equipment efficiency has a direct adverse effect on the unit cost of solids prevented from washing off streets.

This analysis was conducted using total street solids as the quantity in account. However, the constituents of street solids of particular interest from a water quality viewpoint are generally reported as a percent of the total solids (e.g., organics, nutrients, heavy metals). Typical constituent percentage factors for each study area can be applied to the total streets solids results tabulated here to convert the values to the components of total solids of interest.

Conclusions

1) In Alameda County and the City of San Jose the unit cost of preventing solids from washing off the street is less in the wet season than in the

TABLE 8

CITY OF SAN JOSE
(30% SWEEPER EFFICIENCY)

Alternative	Season						Total Washoff Prevented (1000s lb/yr)	Total Cost (1000s $/year)	Unit Cost ($/lb)
	Sept. - Mar.			Apr. - Aug.					
	Res.	Com.	Ind.	Res.	Com.	Ind.			
1			M				153	12	.08
2			B				259	25	.10
3		M	B				515	54	.10
4		B	B				720	87	.12
5		B	W				794	111	.14
6	M	B	W				1670	271	.16
7	M	W	W				1870	332	.18
8	B	W	W				2650	509	.19
9	W	W	W				3600	842	.23
10	W	W	D				3720	1040	.28
11	W	D	D				4120	1530	.37
12	D	D	D				6460	4210	.65
13	D	D	D	M			6480	4340	.67
14	D	D	D	M	M		6480	4360	.67
15	D	D	D	B	M		6500	4510	.69
16	D	D	D	B	B		6510	4530	.70
17	D	D	D	W	B		6530	4800	.73
18	D	D	D	W	W		6540	4850	.74
19	D	D	D	W	W	M	6540	4860	.74
20	D	D	D	W	W	B	6540	4870	.74
21	D	D	D	W	W	W	6540	4890	.75
22	D	D	D	D	W	W	6630	7050	1.06
23	D	D	D	D	D	W	6640	7440	1.12
24	D	D	D	D	D	D	6650	7600	1.14

M = Monthly
B = Biweekly
W = Weekly
D = Daily

TABLE 9

CITY OF SAN JOSE
(20% SWEEPER EFFICIENCY)

Alternative	Season						Total Washoff Prevented (1000s lb/yr)	Total Cost (1000s $/year)	Unit Cost ($/lb)
	Sept. - Mar.			Apr. - Aug.					
	Res.	Com.	Ind.	Res.	Com.	Ind.			
1			M				124	12	.10
2			B				214	25	.12
3		M	B				407	54	.13
4		M	W				485	79	.16
5		B	W				650	111	.17
6		W	W				831	172	.21
7	M	W	W				1450	332	.23
8	B	W	W				2030	509	.25
9	W	W	W				2820	842	.30
10	W	W	D				2950	1040	.35
11	W	D	D				3380	1530	.45
12	D	D	D				5740	4210	.73
13	D	D	D	M			5750	4340	.75
14	D	D	D	M	M		5750	4360	.76
15	D	D	D	B	M		5760	4510	.78
16	D	D	D	B	B		5770	4530	.79
17	D	D	D	W	B		5790	4800	.83
18	D	D	D	W	W		5790	4850	.84
19	D	D	D	W	W	M	5790	4860	.84
20	D	D	D	W	W	B	5790	4870	.84
21	D	D	D	W	W	W	5790	4890	.84
22	D	D	D	D	W	W	5880	7050	1.20
23	D	D	D	D	D	W	5890	7440	1.26
24	D	D	D	D	D	D	5890	7600	1.29

M = Monthly
B = Biweekly
W = Weekly
D = Daily

dry season. The wet season scheduling should begin before the first significant rain of the season.

2) The sweeping priority between land uses is determined by the sweeping efficiency and solids accumulation rate for each land use. In Oakland and North Alameda County, industrial areas have the highest priority and commercial areas the lowest. Other Alameda County areas have no land use areas priority differential. In San Jose, residential areas have the highest priority and industrial areas the lowest in the dry season. The priority is reversed during the wet season.

3) Sweeping streets according to the schedules suggested by the solids washoff model are estimated to be more cost effective on a water quality basis than current programs by a factor of two or more.

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PROGRAM LISTING FOR STREET SOLIDS WASHOFF MODEL

```
// JOB ,DLVR),'ABAG,RUSSELL.202.40',CLASS=Y
// EXEC FORTGCLG,REGION=150K
//FORT.SYSIN DD *
C      TITLE,STREEP
C
C  GIVEN RAIN SCHEDULE, SWEEPING EFFICIENCY, AND SOLIDS ACCUMULATION
C  RATES, THIS PROGRAM CALCULATES:  SOLIDS SWEPT, SOLIDS WASHED OFF,
C  NUMBER OF PASSES FOR EACH SEASON, AND THE UNIT COSTS.
C
C  REQUIRED INPUTS:
C         LINE 1, SPACES 1 & 2
C      LM:  NUMBER OF LOCATIONS (UP TO 4)
C      LUM:  NUMBER OF LAND USES PER LOCATION (UP TO 3)
C
C        NEXT L LINES, LEFT JUSTIFY ON EACH LINE
C      LOC(L):  NAME OF EACH LOCATION
C
C        NEXT LU LINES, LEFT JUSTIFY ON EACH LINE
C      USE(LU):  NAME OF EACH LAND USE
C
       INTEGER KS, LUM, LM
C
C        NEXT L LINES, LU F6.1 ENTRIES ABUTTING EACH OTHER
C      SL(L,LU):  AVERAGE STREET SOLIDS LOAD FOR EACH LOCATION
C          AND LAND USE.
C
C        NEXT L LINES, LU F8.4 ENTRIES ABUTTING EACH OTHER
C      SLS(L,LU):  SLOPE OF THE SOLIDS LOADING RATE CURVE  -
C          DAY'S LOAD INC. = LOAD X SLOPE + MAX. LOADING RATE
C
C        NEXT L LINES, LU F7.2 ENTRIES ABUTTING EACH OTHER
C      SLM(L,LU):  MAXIMUM STREET SOLIDS LOADING RATE IN LBS PER
C          CURB MILE PER DAY FOR EACH LOCATION AND LAND USE.
C
C        NEXT L LINES, LU F5.3 ENTRIES ABUTTING EACH OTHER
C      SE(L,LU):  STREET SWEEPING EFFICIENCY FOR EACH LOCATION
C          AND LAND USE.
C
C        NEXT LINE, L F6.2 ENTRIES ABUTTING EACH OTHER
C      SC(L):  SWEEPING COSTS FOR EACH LOCATION IN DOLLARS PER
C          CURB MILE PER PASS.
C
       REAL R(1460), RA(4), RT, SE(4,3), SR(2), CR(2), SL(4,3),
      +RR12(730), RR34(730), SLS(4,3)
C
C        NEXT L LINES, LU F6.1 ENTRIES ABUTTING EACH OTHER
C      CM(L,LU):  CURB-MILES FOR EACH LOCATION AND LAND USE.
C
C        NEXT LINE, LEFT JUSTIFY F4.3
C      RT:  THRESHOLD RAINFALL IN INCHES PER DAY.
C
C        NEXT LINE, L F5.3 ENTRIES ABUTTING EACH OTHER
C      RA(L):  RAINFALL ADJUSTMENT FACTOR.
```

```
C
C   VARIABLES AND ARRAYS:
      REAL WD(2,10,3), LOC(4,5), USE (3,3), NP(2,10), NF(2),
     +UC(2), AP(2), SC(4), SEA(2,5), SEC(2), USP(2),
     +SLM(4,3), I, WDF(2), UWF(2,10,3), CM(4,3), WFT(2), SCT(2)
      REAL NPS(2), SPP, SPPS, P1(2,3), P2(2,3), P4(2,3), P6(2,3),
     +SPY1, SS2, SPY2, SP12, SS1, B1, B2, A, RSLD(2,3), RINT(2,3),
     +PSEE(2,3)
C
C   FIRST TWO YEARS OF RAINFALL RECORD:  10/1/69 THROUGH 9/30/71.
C
      DATA RR12/9*.0,.03,3*.0,.03,.36,.19,.01,18*.0,.79,.13,.01,
     +26*.0,.01,3*.0,.27,.0,.08,.01,6*.0,.06,.28,.03,.51,2*.0,.01,
     +.31,14*.0,.66,.04,.65,.02,.04,.95,.26,.2,.08,.0,.1,.31,.19,.0,
     +.19,.05,2*.0,.28,12*.0,.14,.01,.02,.13,.34,2*.0,.23,.05,9*.0,
     +.27,.31,1.05,2*.0,1.01,3*.0,.07,.04,.01,33*.0,.13,5*.0,.05,
     +6*.0,.03,13*.0,.02,27*.0,.1,134*.0,.05,.06,.0,.24,10*.0,.3,.36,
     +.14,.53,5*.0,.02,11*.0,.24,.6,.07,.04,2.72,1.13,.07,.46,.38,.
     +.1,3*.0,.01,6*.0,.23,.3,.22,.73,.06,.79,.25,3*.0,.02,.19,.11,
     +.0,.04,2*.0,.1,.01,8*.0,.09,.46,.13,.1,4*.0,.01,.01,26*.0,.24,
     +.0,.13,.03,7*.0,.14,12*.0,.58,.02,.25,8*.0,.14,.0,.25,.32,5*.0,
     +8*.0,.12,.03,2*.0,.38,2*.0,.16,.34,.0,.02,12*.0,.03,10*.0,.01,
     +13*.0,.02,.01,.01,86*.0,.01,36*.0,.12/
C
C   SECOND TWO YEARS OF RAINFALL RECORD:  10/1/71 THROUGH 9/30/73.
C
      DATA RR34/41*.0,.06,.12,.26,
     +13*.0,.01,.17,.08,2*.0,.68,.09,2*.0,.02,2*.0,.02,.11,.0,.03,.0
     +.01,7*.0,.56,.28,.11,.69,.0,.6,.0,.09,20*.0,.01,3*.0,.08,.0,
     +.22,.03,.86,.01,5*.0,.02,.05,.22,16*.0,.03,5*.0,.01,21*.0,.07,
     +13*.0,.09,.05,4*.0,.09,.0,.11,10*.0,.17,45*.0,.14,108*.0,.01,
     +.59,4*.0,.01,.0,.02,4*.0,.33,.34,.08,.15,.04,.44,.26,.4,.1,.02,
     +15*.0,.02,.72,2*.0,.17,2*.0,.58,1.23,.0,.65,1.23,.39,.44,.0,
     +.02,.03,13*.0,.03,.09,.0,.31,.26,.01,7*.0,.04,.24,.03,.07,2*.0
     +.02,.0,.03,3*.0,.05,10*.0,.4,.97,.07,.16,4*.0,1.38,.22,.8,.02,
     +.0,.12,3*.0,.3,3*.0,.07,.57,.04,2*.0,.31,.69,.0,1.08,.15,.0,
     +.04,.37,.78,.16,.5,.25,9*.0,.21,.0,.53,.65,.25,2*.0,.44,.13,.
     +.34,.0,.27,2*.0,.21,7*.0,.25,.66,.35,4*.0,.02,3*.0,.06,
     +.02,12*.0,.04,.01,39*.0,.01,121*.0,.01,.03,6*.0/
      DO 5 I=1,730
      R(I)=RR12(I)
      R(I+730)=RR34(I)
    5 CONTINUE
      DATA SEA/'SEPT','APRI','EMBE','L TH',
     +'R TH','RU A','RU M','UGUS','ARCH','T   '/
      IDIN=5
      IDOUT=6
C
C   READ THE JOB INPUTS.
C
      READ (IDIN,10) LM, LUM
   10 FORMAT (2I1)
      READ (IDIN,15) ((LOC(J,K), K=1,5), J=1,LM)
   15 FORMAT (5A4)
      READ (IDIN,20) ((USE(J,K),  K=1,3), J=1,LUM)
   20 FORMAT (3A4)
```

```
      READ (IDIN,25) ((SL(J,K), K=1,LUM), J=1,LM)
   25 FORMAT (3F6.1)
      READ (IDIN,27) ((SLS(J,K), K=1,LUM), J=1,LM)
   27 FORMAT (3F8.4)
      READ (IDIN,30) ((SLM(J,K), K=1,LUM), J=1,LM)
   30 FORMAT (3F7.2)
      READ (IDIN,35) ((SE(J,K), K=1,LUM), J=1,LM)
   35 FORMAT (3F5.3)
      READ (IDIN,40) (SC(J), J=1,LM)
   40 FORMAT (4F6.2)
      READ (IDIN,25) ((CM(J,K), K=1,LUM), J=1,LM)
      READ (IDIN,45) RT
   45 FORMAT (F4.3)
      READ (IDIN,46) (RA(J), J=1,LM)
   46 FORMAT (4F5.3)
C
C  EXAMINE EACH LOCATION.
C
      DO 300 L=1,3
      WRITE (IDOUT,105)
  105 FORMAT ('1ABAG - STREET SWEEPING EFFECTIVENESS MODEL',
     +/,'         BY PETER RUSSELL, MARCH 1980',//)
      WRITE (IDOUT,110) (LOC(L,K), K=1,5)
  110 FORMAT ('0', 10X, 5A4, //)
C
C  PRINT OUT THE PARAMETERS USED FOR THE LOCATION.
C
      WRITE (IDOUT,112)
  112 FORMAT ('    LAND USE     AVE. LOAD     ACCUM. SLOPE', 4X,
     +'MAX. ACCUM RATE', 7X, 'SWEEPING', 8X, 'CURB-MILES', /, 16X,
     +'LB/C-MI', 24X, 'LB/C-MI/DAY', 8X, 'EFFICIENCY',//)
      DO 400 LU=1,LUM
  400 WRITE (IDOUT,114) ((USE(LU,K), K=1,3), SL(L,LU), SLS(L,LU),
     +SLM(L,LU), SE(L,LU), CM(L,LU))
  114 FORMAT ('0',3A4,4X,F5.0,12X,F7.4,9X,F6.2,13X,F4.3,12X,F6.1)
      WRITE (IDOUT,116) SC(L)
  116 FORMAT (//, '0STREET SWEEPING COST:  $', F5.2, '/C-MI/PASS.')
      WRITE (IDOUT,118) RA(L), (LOC(L,K), K=1,5), RT
  118 FORMAT('0RAINFALL ADJUSTMENT FACTOR  = ', F4.2, ' FOR ',
     +5A4, '.', //, ' THE THRESHOLD RAINFALL FOR COMPUTING',
     +' WASHOFF IS ', F3.2, ' INCHES/DAY.')
      DO 350 I=1,2
      DO 350 J=1,LUM
      R1(I,J)=0.
      R2(I,J)=0.
      R4(I,J)=0.
      R6(I,J)=0.
  350 CONTINUE
C
C  EXAMINE SWEEP PERIODS OF 1, 2, 4, 7, 11, 16, 22, 29 AND 37 DAYS.
C
      SP=1.
      DO 200 KA=1,10
      SP=SP+KA-2
      IF (KA.EQ.1) SPR=0.
      IF (KA.EQ.1) SPRS=0.
```

```
      DO 200 LU=1,LUM
      IF (KA.EQ.1) SP=9999.
C
C  SET THE BOOKKEEPING VARIABLES EQUAL TO ZERO.
C
      DO 500 KS=1,2
      NP(KS,KA)=0.
      IF (KA.EQ.1) NPS(KS)=0.
      SR(KS)=0.
      NR(KS)=0.
      WD(KS,KA,LU)=0.
      CR(KS)=0.
  500 CONTINUE
C
C  EXAMINE EACH LAND USE IN THE LOCATION.
C
      SS=SL(L,LU)
      WRITE (IDOUT,105)
      WRITE (IDOUT,110) (LOC (L,K), K=1,5)
      WRITE (IDOUT,120) SP
  120 FORMAT (' FOR A SWEEPING FREQUENCY OF ONCE EVERY ',
     + F5.0, ' DAYS:')
      WRITE (IDOUT,125) (USE(LU,K), K=1,3)
  125 FORMAT (' ', 3A4, 'LAND USE:', /)
C
C  RUN FOUR YEAR'S RAIN DATA SEVEN TIMES, EACH BEGINNING
C       WITH A DIFFERENT DAY OF THE WEEK.
C
      D=0.
      NY=7
      DO 100 II=1,NY
C
C  RUN FOUR YEAR'S DATA.
C
      DO 100 I=1,1460
      D=D+1
C
C  ADD DAY'S INCREMENT OF SOLIDS TO THE STREET SURFACE.
C
      SS=SS+SLS(L,LU)+SLM(L,LU)
C
C  IDENTIFY THE SEASON:  1=NOVEMBER THRU MARCH, 2=APRIL THRU AUGUST.
C
      KS=2
      IF ((I.LE.182).OR.((I.GE.336).AND.(I.LE.547)).OR.((I.GE.701)
     +.AND.(I.LE.912)).OR.((I.GE.1066).AND.(I.LE.1277)).OR.
     +(I.GE.1431)) KS=1
C
C  IS THE DAY A MULTIPLE OF THE SWEEP PERIOD?
C
      M=0
      IF (D/SP-AINT(D/SP).NE.0.) M=1
C
C  IS THE DAY A SUNDAY OR SATURDAY?
C
      IF(((D-1)/7.-AINT((D-1)/7.).EQ.0.).OR.(D/7.-
     +AINT(D/7.).EQ.0.)) M=1
```

?

```
C
C   IS THE DAY A MONDAY FOLLOWING A WEEKEND MULTIPLE OF THE SWEEP
C       PERIOD?
C
      IF (((D-2)/7.-AINT((D-2)/7.).EQ.0.).AND.(((D-1)/SP-
     +AINT((D-1)/SP).EQ.0.).OR.((D-2)/SP-AINT((D-2)/
     +SP).EQ.0.))) M=0
C
C   IS THE DAY'S RAIN ABOVE THE THRESHOLD?
C
      IF (R(I)*RA(L).GE.RT) GO TO 50
C
C   IS SWEEPING TO BE DONE?
C
      IF (M.EQ.1) GO TO 100
      IF (SP.EQ.9999.) GO TO 100
C
C   SWEEP THE STREET, TALLY SOLIDS AND COUNT THE PASS.
C
      NP(KS,KA)=NP(KS,KA)+1
      SR(KS)=SR(KS)+SS*SE(L,LU)
      SS=SS*(1-SE(L,LU))
      GO TO 100
C
C   RAIN EVENT:  TALLY SOLIDS, COUNT THE RAIN DAY AND TALLY RAIN.
C
   50 NR(KS)=NR(KS)+1
      WO(KS,KA,LU)=WO(KS,KA,LU)+SS*(1-EXP(-3.91*R(I)*RA(L)))
      SS=SS*EXP(-3.91*R(I)*RA(L))
      CR(KS)=CR(KS)+(R(I)*RA(L))
  100 CONTINUE
      IF ((LU.EQ.1).AND.(KA.NE.1)) SPR=SPR+1/SP
      IF ((LU.EQ.1).AND.(KA.NE.1)) SPRS=SPRS+(1/SP)**2
      DO 200 KS=1,2
      NP(KS,KA)=NP(KS,KA)/(4*NY)
      IF (LU.EQ.1) NPS(KS)=NPS(KS)+NP(KS,KA)
      SR(KS)=SR(KS)/(4*NY)
      NR(KS)=NR(KS)/(4*NY)
      WO(KS,KA,LU)=WO(KS,KA,LU)/(4*NY)
      WOF(KS)=WO(KS,1,LU)-WO(KS,KA,LU)
      CR(KS)=CR(KS)/(4*NY)
      AR(KS)=CR(KS)/NR(KS)
      SEC(KS)=SC(L)*NP(KS,KA)
      IF (NP(KS,KA).EQ.0.) GO TO 900
      UC(KS)=SC(L)*NP(KS,KA)/SR(KS)
      USR(KS)=SR(KS)/NP(KS,KA)
      UWF(KS,KA,LU)=SC(L)*NP(KS,KA)/WOF(KS)
      GO TO 800
  900 USR(KS)=0.
      UC(KS)=0.
      UWF(KS,KA,LU)=0.
  800 CONTINUE
      WFT(KS)=WOF(KS)*CM(L,LU)
      SCT(KS)=SEC(KS)*CM(L,LU)
```

```
C
C  TABULATE THE RESULTS FOR EACH SEASON.
C
      WRITE (IDOUT,150) (SEA(KS,K), K=1,5)
  150 FORMAT (' ', 24X, 6A4)
      WRITE (IDOUT,152) NR(KS), CR(KS), AR(KS)
  152 FORMAT ('0', F5.1, ' SIGNIFICANT RAIN DAYS.', 12X,
     +'CUMULATIVE TOTAL  = ', F4.1, ' INCHES/SEASON.',
     +/, ' THE AVERAGE RAIN  = ', F4.2, ' INCHES/DAY.')
      WRITE (IDOUT,154) NP(KS,KA), SP(KS), USP(KS), SEC(KS), UC(KS),
     +WO(KS,KA,LU)
  154 FORMAT ('0ACTIVITY  = ', F5.1, ' PASSES/SEASON.',
     +/, '0SOLIDS SWEPT UP  = ', F7.1, ' LB/C-MI  = ', F8.2,
     +' LB/C-MI/PASS.', /, ' SWEEPING COST  =  $', F8.2,
     +'/C-MI/SEASON  =  $', F6.3, '/LB SWEPT UP.', /,
     +'0WASHOFF  = ', F7.1, ' LB/C-MI/SEASON.')
      WRITE (IDOUT,156) WOF(KS), UWF(KS,KA,LU)
  156 FORMAT ('0WASHOFF FORGONE  = ', F7.1, ' LB/C-MI/SEASON  =  $',
     +F8.3, '/LB PREVENTED FROM WASHING OFF.')
      WRITE (IDOUT,158) WFT(KS), SCT(KS)
  158 FORMAT (' TOTAL WASHOFF FORGONE  = ', F10.0, ' LB/SEASON.',
     + '      TOTAL COST  =  $', F10.0, '/SEASON.', //)
      IF (KA.EQ.1) SP=1
      IF (KA.EQ.1) GO TO 200
      R1(KS,LU)=R1(KS,LU)+1
      R2(KS,LU)=R2(KS,LU)+UWF(KS,KA,LU)/SP
      R4(KS,LU)=R4(KS,LU)+UWF(KS,KA,LU)
      R6(KS,LU)=R6(KS,LU)+(UWF(KS,KA,LU))**2
  200 CONTINUE
      WRITE(IDOUT,105)
      WRITE (IDOUT,110) (LOC(L,K), K=1,5)
      WRITE(IDOUT,162)
  162 FORMAT(' THE BEST FIT COEFFICIENTS DEFINING THE',
     +' UNIT COST OF SOLIDS KEPT FROM WASHING OFF ARE:', /,
     +15X, '$/LB  =  A X (1/SWEEP PERIOD) + B')
      DO 300 KS=1,2
      WRITE (IDOUT, 163)
  163 FORMAT (/)
      WRITE (IDOUT,150) (SEA(KS,K), K=1,5)
      DO 310 LU=1,LUM
      RSLO(KS,LU)=(R1(KS,LU)*R2(KS,LU)-SPR*R4(KS,LU))/
     +(R1(KS,LU)*SPRS-SPR**2)
      RINT(KS,LU)=(R4(KS,LU)*SPRS-SPR*R2(KS,LU))/
     +(R1(KS,LU)*SPRS-SPR**2)
      RSEE(KS,LU)=SQRT((R6(KS,LU)-RINT(KS,LU)*R4(KS,LU)-
     +RSLO(KS,LU)*R2(KS,LU))/(R1(KS,LU)-2))
      WRITE (IDOUT,164) (USE(LU,K), K=1,3), RSLO(KS,LU), RINT(KS,LU),
     +RSEE(KS,LU)
  164 FORMAT ('0', 3A4, 10X, 'A  = ', F9.5, 10X, 'B  = ', F9.5, /,
     +' STANDARD ERROR OF ESTIMATE  =  $', F7.3, '/LB.')
  310 CONTINUE
      SPY1=0.
      SS2=0.
      SPY2=0.
      SP12=0.
      SS1=0.
      SP=1.
```

```
            DO 330 KA=2,10
            SP=SP+KA-2
            SPY1=SPY1+(NP(KS,KA)-SPR/R1(KS,1))◆(1/SP-SPR/R1(KS,1))
            SS2=SS2+((1/SP)◆◆2-SPRS/R1(KS,1))◆◆2
            SPY2=SPY2+(NP(KS,KA)-SPR/R1(KS,1))◆((1/SP)◆◆2-SPRS/R1(KS,1))
            SP12=SP12+(1/SP-SPR/R1(KS,1))◆((1/SP)◆◆2-SPRS/R1(KS,1))
            SS1=SS1+(1/SP-SPR/R1(KS,1))◆◆2
        330 CONTINUE
            B1=(SPY1◆SS2-SPY2◆SP12)/(SS1◆SS2-(SP12)◆◆2)
            B2=(SPY2◆SS1-SPY1◆SP12)/(SS1◆SS2-(SP12)◆◆2)
            A=NPS(KS)/R1(KS,1)-B1◆SPR/R1(KS,1)-B2◆SPRS/R1(KS,1)
            WRITE (IDOUT,170) (SEA(KS,K), K=1,5), A, B1, B2
        170 FORMAT ('0NUMBER OF PASSES DURING ', 5A4, '= ', F7.3, ' + ',
           +F8.3, ' X (1/SWEEP PERIOD) + ', F8,3, ' X (1/SWEEP PERIOD)◆◆2.'
           +, //)
        300 CONTINUE
            STOP
            END
      /◆
      //GO.SYSIN DD ◆
      33
      CITY OF SAN JOSE
      CITY OF SAN JOSE
      CITY OF SAN JOSE
      RESIDENTIAL
      COMMERCIAL
      INDUSTRIAL
       489.1 757.6 626.7
       489.1 757.6 626.7
       489.1 757.6 626.7
         .9722    .9859    .9961
         .9722    .9859    .9961
         .9722    .9859    .9961
        30.56  24.47  15.32
        30.56  24.47  15.32
        30.56  24.47  15.32
       .365 .323 .36
       .3   .3   .3
       .2   .2   .2
       14.00 14.00 14.00
      1770.  324.2 130.4
      1770.  324.2 130.4
      1770.  324.2 130.4
      .2
      1.   1.   1.
      /◆
      //
?
```

WQ/TECH MEMO #39/May 1980
Emy Chan

WATER QUALITY MANAGEMENT PLAN

RECREATION AND OPEN SPACE BENEFITS OF WATER POLLUTION CONTROL PROGRAMS

Technical Memorandum No. 39

December 10, 1979
Revised May 23, 1980

I. INTRODUCTION

Objective

The connection between water pollution control programs and recreation is often expressed in general terms of less pollution leads to "fishable and swimmable" waters. A coordinated program for controlling pollution in San Francisco Bay aims at an overall improvement in water quality through upgraded facilities and better management. Maintenance of good water quality ensures the safety of water-contact recreation and promotes a healthy environment that can support other forms of water-associated recreation such as fishing and nature observation.

These benefits are typically spread out over a large area and an individual waste discharger or implementing agency may not be able to justify additional expenditures and effort when it is difficult to substantiate their direct contribution to recreation and open space opportunities. Facility planners and agencies responsible for implementing water quality programs need a way to identify the recreational opportunities that may result.

The objective of this technical memorandum, therefore, is to identify the types of direct and indirect benefits that can be accrued from water quality programs, the mechanisms for their implementation and methods for assessing costs and recreational values. The memo is intended to serve as a guideline to planners and implementing agencies for assessing the recreational and open space benefits that could be derived from their programs and projects. The memo also suggests mechanisms for coordination of State, regional and local recreation programs with water quality facilities.

The Recreation Environment

Recreation and open space associated with San Francisco Bay provide an important link between our daily activities and how we relate to the Bay environment. This may be embodied in practical aspects such as picnic tables, playing fields or a fishing pier and marina. Yet, it is also a matter of feelings such as the appreciation of an open shoreline stretching for miles in either direction, the thrill from a bite on a fishline or the salty taste of a crisp sea breeze. These perceptions, although unquantifiable, contribute collectively to the Bay experience.

The San Francisco Bay Area offers a variety of recreational opportunities. The Bay and Delta, as well as local streams and lakes, are attractive to recreationists seeking fishing, swimming, boating, nature watching and other experiences. Shoreline parks, strands of natural marsh communities and meandering sloughs form the most important part of the local open space resource. Access to these water bodies and the shoreline itself have changed over time through increasing urban development, Bay filling, governmental regulatory actions and public acquisition of land. The suitability and capability of these water bodies to support recreation has also fluctuated as human activities have altered the quality of the water and the adjacent shoreline. An important goal of local and regional planning activities is the provision of public access along with the restoration and enhancement of shoreline areas to maximize recreation opportunities and open space resources.

Recreation in the Context of Water Quality Planning

About $300 million could be spent annually for the Water Quality Management Program under the Environmental Management Plan. The largest portion of this--$200 to $240 million--will go towards the construction and operation of municipal and industrial wastewater treatment facilities. The facilities construction costs are underwritten up to 87-1/2 percent by Federal funds designated under P.L. 92-500, the Water Pollution Control Act of 1972, and State funds.

Programs of this magnitude can cause serious impacts on natural systems, but they can also create important opportunities to serve human needs. P.L 92-500 recognized that restoration and improvement of water associated recreation opportunities was an important goal of an areawide Section 208 water quality management program. Best Practicable Wastewater Treatment Technology was mandated nationwide with the goal of making local waters "fishable and swimmable" by 1983. The 1977 Act Amendments (P.L. 95-217) further require thay any plan prepared under Section 208 must include: "an identification of open space and recreation opportunities that can be expected to result from improved water quality, including consideration of potential use of lands associated with treatment works and increased access to water-based recreation."

The importance of coordination of federally-funded programs with enhancement of recreational interests has been emphasized in the National Urban Recreation Study and the 1978 Nationwide Outdoor Recreation Plan. It is within the above context that this paper identifies recreation and open space opportunities associated with water quality improvements under the implementation of the ABAG Environmental Management Plan.

Recreation Goals-ABAG Regional Plan

The ABAG Regional Plan contains four objectives relating to recreation: (1) provision of regional recreation facilities which cannot be provided by local governments; (2) meeting the needs of special groups whose communities are unable to provide adequate opportunities; (3) supplying certain specialized recreational experiences; and (4) maintaining and improving visual quality of the region. Policies relating to water-associated recreation are:

Policy 1. Recreational opportunities should be available in or near urban areas.

Policy 2. Priority should be given to protecting open space within and immediately around urbanized areas.

Policy 3. Secure public open space while it is available.

Policy 4. Improve visual quality of the region.

Policy 6. Promote the following types of regional parklands:

- a. Regional Recreation Area
- b. Regional Park
- c. Regional Wilderness
- d. Regional Shoreline
- e. Regional Trail
- f. Regional Landscape

Policy 7. Protect features of land and water areas of critical regional concern for Scenic Resources and Regional Landscapes, such as San Francisco Bay.

ABAG advocates the following actions regarding recreation funding:

- o Increased State and Federal funds to expand opportunities for recreation planning, site acquisition and development.

- o Improved integration among State and Federal financial assistance and regulatory programs for environmental quality, parks and recreation, housing, economic development, manpower training, etc.

II. COMPONENTS OF RECREATION AND OPEN SPACE

Definitions

Recreation--This is generally defined as activities which renew and refresh one's spirit, particularly after work or other tiring conditions. Recreation opportunities may be derived from experiences with the surrounding environment, or may occur in areas specifically set aside for recreation, such as playing fields. The U.S. Forest Service suggests in its Wildland Planning Glossary a definition of recreation:

> "Recreation is an exceedingly variable term meaning almost anything people do with their leisure. It is not a resource but an activity compounded of two parts, recreationists and recreation environments. Resources such as timber, forage, water or minerals exist in land. Recreation exists in the mind and takes place in an environment based on the land."

The focus of this paper is on recreation opportunities associated specifically with surface water bodies and the Bay environment--as these can be affected by water pollution control programs. Key to this analysis is the conservation of natural resources with the dual purpose of providing recreation environments.

Open Space--This term generally refers to those natural and semi-natural areas which have not been developed for residential, commercial or industrial uses. These may be areas used for agriculture, parks, water bodies and military reservations. In urban areas, open space extends to include smaller parcels and land which has a low intensity of development over large areas, such as airports, industrial salt ponds and cemetaries.

The natural geography of the Bay Area includes concentrated population and urban development centers within the valleys and inner coastal areas. Soil and geologic unsuitability have forced development away from the foothills and the Baylands. In an age when valuable land resources are consumed by urban sprawl, recognition and preservation of the remaining open space becomes mandatory. In relation to lands adjacent to water bodies, open space can be defined for the following functions:

(1) Open space for the preservation of natural and man-made resources--lands which deserve preservation as open space because of unique or unusual natural or man-made features that would be difficult or impossible to duplicate, and lands that are crucial to rare or unique natural processes, e.g., land, tidelands, marsh and water areas for fish and wildlife refuge, areas to provide amenity.

(2) Open space for Outdoor Recreation--lands suitable for passive and active outdoor recreational pursuits, including lands to fulfill current recreation deficit and potential recreation needs, e.g., lands for water-oriented recreation, lands for natural environmental experience.

Types of Recreation Activities

A number of outdoor recreation activities are prevalent in the Bay Area. The following listing describes their status and relationship to water quality improvements.

Swimming and Sunbathing--Studies done of recreation in the San Francisco Bay indicate these activities as the most popular. A Corps of Engineers study done in the mid-sixties pointed out the impairment of this activity due to pollution. Appearance of the water apparently deterred some people. In other areas, public health agencies actually posted sections of streams or beaches off limits. Improvements in bacterial content and turbidity will create healthier and more aesthetically pleasing conditions for water contact sports.

Sportfishing--The San Francisco Bay and Delta system has long supported sportfishing activities, including salt-water, anadromous, and fresh-water species of fish. For the recreationists, fishing may take the form of boat fishing, shore or pier angling, and in the future shellfishing along tidal flats, or skin diving.

Supporting an increased demand for fishing assumes access to the water bodies and a vital, healthy population of fish. The aquatic environment, influenced by human activities, will determine the ability of the species to remain viable. Pollution has seriously impaired shellfishing in San Francisco Bay; in the past, it has been considered unsafe to consume certain species taken from the Bay (see ABAG report, The Rise and Fall of the Dungeness Crab).

Quality requirements of fish and other aquatic life include parameters such as dissolved materials, pH, alkalinity and acidity, temperature, dissolved oxygen, carbon dioxide, oil, turbidity, settleable materials, color and transparency, floating materials, tainting substances, radionuclides, plant nutrients and nuisance growths, and toxic substances. To the extent that water pollution control measures mitigate these problems the aquatic environment will improve.

Boating--Recreational boating includes both motor boating and sailing; access to water and boating berths as well as boat ramps and parking must be available. Another aspect, less easily quantified, is the aesthetically pleasing environment. It is not clear whether unclean water and nuisance odors have acted as a deterrent. However, improving the aesthetics of the environment can only add to the recreationists' benefits.

Nature Observation--The San Francisco Bay and its associated wetlands support a tremendous variety of birds and wildlife. Many recreationists seek the enjoyment of wildlife and natural surroundings. Bay filling and other urbanizing activities reduced considerably the natural habitats as well as access to recreationists. Improving the health of the aquatic environment and continuing to provide wildlife habitat may be a cumulative and especially crucial benefit of improved water quality. The Bay system will continue to provide appreciators of nature with the opportunity to enjoy the diversity of species for which it is ecologically important.

Hunting--Hunting has been practiced by Bay Area residents and hunters elsewhere in California. The Bay and Delta provide wintering and year-round habitat and breeding areas for huge numbers of upland shore and marsh and game birds. A Corps of Engineers report in the mid-sixties indicated that 25% of the State total kill of waterfowl is taken from Bay Area counties. The number of waterfowl depends on the quality and quantity of suitable habitat.

Picnicking, Camping, Hiking--While not dependent on bodies of water, these activities may be enhanced by proximity to the Bay, lakes, streams of reservoirs. They require sites, facilities and pleasing surroundings. The effect of water quality depends on the extent which recreationists also engage in water-related activities such as nature enjoyment, swimming, and boating. Improved aesthetic and health conditions could contribute to the enjoyment of these particular recreational activities.

III. DIRECT BENEFITS OF WATER QUALITY MANAGEMENT PROGRAMS

Historically, wastewater treatment plants have had a negative public image associated with odors, nuisance, and water quality problems. Upgraded facilities, which were designed to minimize the aesthetic and water quality problems, nevertheless retain the stigma of a sewage treatment plant and the reputation as a poor neighbor.

In the wake of presidential directives and federal legislation mandating the incorporation of recreation opportunities and maintenance of open space conditions into all federally-funded projects, facilities planning now has added a new focus. New facilities are designed to be compatible with surrounding land uses and may have recreation components built into them. Landscaping to preserve the open space character and multi-purpose uses for facilities--such as recreation--can in turn, make treatment plants more agreeable neighbors.

Preservation of Open Space and Natural Features

Treatment facilities, particularly those which serve large areas, are situated in the lowest portion of their service areas to facilitate gravity drainage of sewage and reduce pumping costs. Proximity to a water body is usually required for discharging the treated effluent. Thus, the common denominator for almost all of the Bay Area treatment facilities is their location on or near the Bay shore.

In the South Bay, the extensive, flat baylands lead to low visual angles which reduce the perception of the Bay to almost no significant water-associated images. On both sides of the Bay, land forms created by landfills and man-made structures become visually more relevant than the Bay itself. Thus, the design of wastewater facilities near the bayshore and the surrounding land use can have a strong effect upon the open space and natural character of an area.

The intensiveness of land use by treatment facilities varies with the method of treatment used. Mechanical systems are generally more compact with a visible structure while land-based systems exhibit a low profile and consume significant acreages. Both types of systems can be designed to be compatible with natural contours and to incorporate or build around natural features.

The following is a list of considerations for facilities planning that can be compatible with open space and natural features:

(1) Where possible, facilities could be set back from the shoreline to retain the open character of the waterfront area. Siting near prominent features such as behind an existing hill or within an existing grove of trees also helps to retain the existing character.

(2) Structures for treatment facilities can be situated in a cluster or grouped arrangement to minimize consumption of open space.

(3) Facilities can be designed with a low profile and architectural treatment to maintain the continuity of land forms and to blend with the environs.

(4) Landscaping around the facilities can help shield buildings and equipment.

(5) If significant natural features exist within the project site, such as marshes, estuaries, ponds or streams, the facilities should be designed to preserve these features with minimal interference.

(6) Wastewater facilities utilizing a land treatment system as part of the process can contribute to the preservation of open space. Examples are marshes and ponds used for polishing wastewater that do not visually alter landforms and perpetuate open space.

(7) Measures to control erosion and improve the quality of surface runoff can be planned to complement open space. Buffer strips, sediment basins, grassed drainageways and other methods can become part of the open space resource.

<u>Access to Shoreline Areas</u>

Until recently, there were few points of public access in the entire 276-mile Bay shoreline. While many communities have recently taken new looks at their waterfronts and have proposed new points of public access to the Bay, the full potential for Bay access has by no means been achieved. The following features are derived from the <u>San Francisco Bay Plan</u> and could be considered in facilities plans:

(1) Maximum feasible opportunity for pedestrian access to the waterfront should be included in the facilities plan. Bicycle and auto access may be considered, where appropriate.

(2) If significant natural features exist within the project site, public access may be provided to permit enjoyment and study of these ecological assets where compatible with local goals. Examples would be catwalks or piers in some sloughs or marshes.

(3) Whenever public access to the Bay is provided as a condition of development, the access should be permanently guaranteed. This should be done whenever appropriate by requiring dedication of fee title or easements at no cost to the public in the same manner that street and park sites are dedicated to the public in a subdivision process.

(4) Access to the waterfront could be provided by walkways or other means if adjacent parking is not desirable or feasible. In wastewater facilities, pipelines and interceptors are constructed through easements or right-of-ways. The pipeline corridor could double as a walkway or bicycle path for public access. In some cases, this could connect with a regional path/access system.

(5) Roads near the shoreline and access paths could be designed as scenic parkways for slow-moving, principally recreational traffic. The right-of-way design should discourage through traffic and provide for safe pedestrian access to the shore.

(6) Facilities planning should be coordinated with the Bay Conservation and Development Commission to maximize access opportunities.

<u>Multi-Purpose Use of Facilities</u>

Some of the land used for wastewater facilities can become community recreation areas. This requires an assessment of local recreation needs and community input on the desirability and acceptability of certain features. The following list is an example of multi-purpose uses of facilities that would enhance recreation opportunities:

(1) Bicycle, hiking and horseback riding trails can be accommodated on sewer pipeline right-of-ways.

(2) Wastewater treatment facilities can also serve as environmental education sites with instructive exhibits, labeling of plant components and guided tours by plant operators.

(3) One community built tennis courts atop its sewage plant's large settling tank. Designing the plant with recreational facilities in mind can reduce the cost of those facilities.

(4) For facilities that are situated on large grounds, particularly those in scenic areas, provision could be made for picnic areas, ball fields, and space for many types of recreational activity. This helps to promote the "good neighbor" image.

(5) Open space left along streambanks and shorelines on plant sites provides areas for public recreation and enjoyment.

(6) Outdated treatment plants or portions of plants can be converted into recreation centers. In Monticello, Arkansas an abandoned sewage treatment facility was transformed into a recreation area with a swimming pool, bathhouse, playgrounds, playing fields, tennis courts and roller rink. The final product was so well received by the town and the state, that Monticello was awarded the Outstanding Land and Water Conservation award. The award is part of the Heritage Conservation and Recreation Service in the U.S. Department of Interior.

Reclaimed Water and Recreational Benefits

In water-short areas, wastewater itself, becomes a commodity that can be transported, marketed and used. All treatment facilities are currently or projected to be treating wastewaters to a secondary treatment level. This entails removal of as much as 90 percent of the organic matter in sewage. A number of the treatment plants discharging into recreational and shellfish waters along the Bay front are also required to use advanced treatment methods to remove pathogenic organisms, reduce the nutrient load and cut down the suspended solids. Thus, treated wastewater can be of good enough quality for recycling to other uses. In California, the water quality standard for wastewater reuse is dictated by Title 17 of the California Administrative Code.

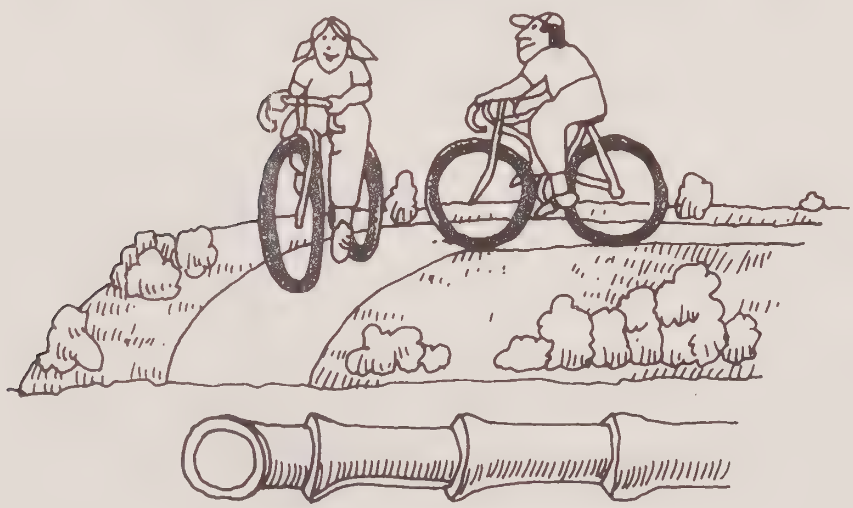
Generally, the main limiting factors for reclamation of wastewater are:

- The economics of using wastewater--after all the levels of treatment, is recycled water competitive on a unit cost basis with other sources of water supply?

- The distance between the reclaimed water source (the treatment plant) and the actual usage area--if the usage area is several miles away or at a higher elevation, then pumping costs may make operation of the system very expensive.

- Public health concerns--advanced treatment can remove almost all of the pathogenic organisms, but a small amount will remain. Viruses are particularly troublesome in this aspect. What are the acceptable levels of risk for residual bacteria and viruses?

CREATING NEW RECREATION OPPORTUNITIES WITH RECLAIMED WATER. At Santee, California, secondary-treated wastewater filters through a series of soil filters and lagoons. The resultant water is of such good quality that people can swim, boat and fish in the final lake.



PIPE TRAIL RIDING
Trails for bicyclists, hikers and horseback riders have been built above buried sewer pipelines. By planning ahead, communities can acquire the right to use these surface paths when acquiring the right to bury the pipes.

- o Reclaimed water storage--water usage would probably be on a non-continuous basis (e.g., diurnal, semi-weekly, weekly, etc.); yet wastewater is generated 24 hours a day and has to go somewhere. Storage facilities, sometimes for enormous volumes in limited areas, would be required.

- o Public acceptance--reclaimed water will carry the stigma of its sewage origin to some extent. Is there justifiable cause for their concern? Can people be re-educated to revise their thinking?

A number of implementing agencies and districts in the Bay Area are considering usage of reclaimed water or are trying it on a limited scale. On a national level, recyling of wastewater is being applied to some innovative uses and also being re-introduced to some more traditional uses. The following is a list of potential uses and some working examples of wastewater reclamation is applicable to recreation and open space enhancement:

(1) Wastewater treatment lagoons, particularly those in the final "polishing" stage (nearest to a clean end product) can be used for recreation. At Santee, California, secondary-treated water filters through a series of lakes and soil filters. The resultant water is of such good quality that people can swim, boat and fish in the final lake.

The Chain of Lakes in San Francisco's Golden Gate Park is filled with treated wastewater. Although contact sports are not allowed, the lakes do provide important visual amenities that complement the park's recreation resources.

(2) Treated wastewater can be used to augment or even create new freshwater marshes. At the Mountain View Sanitary District in Martinez, California, 20 acres of wetlands were created to handle 1.5 million gallons/day of effluent. The marsh habitat and wildlife attract nature observers and educational classes. The marsh itself provides visual open space relief from the refineries on the adjoining hillsides.

The Coyote Hills Regional Park in Fremont contains 50 acres of freshwater marsh, part of it created by pumping and collecting 900 acre-ft/yr of freshwater into the park at $45/acre-foot. With the potential implementation of the East Bay Dischargers Authority Reclamation Reuse Project, the park's share of costs for receiving a dependable year-around supply of reclaimed water would be $21/acre-foot.

(3) The organic component in wastewater can be used to support aquaculture. The Arkansas Game and Fish Department raised filter-feeding fish (silver and bighead carp) in wastewater ponds. Water Life West Inc. in San Diego has experimented with raising fish and shrimp in aerated lagoons. Woods Hole Oceanographic Institute in Massachusetts has worked with raising claims, oysters, lobster, flatfish, seaweed and prawns. Although these studies have not been aimed at recreational uses, these systems could present a future option for recreational benefits.

(4) Parks, golf courses and other recreational areas could be irrigated with reclaimed water. This usage must operate within the constraints of pumping distances, public health and public acceptance conditions. Examples of irrigation with effluent are in Golden Gate Park in San Francisco and a score of golf courses throughout California.

(5) Land-based treatment systems and wastewater facilities using land treatment systems can help preserve open space. An example of a land-treatment system is the Palo Alto Flood Basin/Marsh which receives urban runoff and filters out pollutants through the marsh system. This type of flow-through marsh/treatment system could be implemented in many areas along the Bay and perpetuates open space in that area on a long-term basis.

IV. INDIRECT BENEFITS OF WATER QUALITY MANAGEMENT PROGRAMS

The primary effect of water quality management programs is to improve the quality of the water entering the Bay. The level of improvement and criteria for discharge quality is set by the Regional Water Quality Control Board in consultation with regional and local agencies. The pollutants targeted for major removal efforts are pathogenic organisms, organic materials, suspended solids, and nutrients--to the extent feasible. Major cleanup of waters tributary to the Bay can lead to the restoration and maintenance of beneficial uses.

Beneficial Uses of Surface Waters

The Water Quality Control Plan for the San Francisco Bay Basin has identified 113 creeks, lakes, bays, lagoons and reservoirs as having existing and potential beneficial uses. A listing of the 113 water bodies and the 21 identified beneficial uses is presented in Appendix A. The two largest categories of recreation benefits are Water Contact Recreation (REC-1) and Non-Contact Water Recreation (REC-2).

Other beneficial uses directly affecting recreation resources are Ocean Commercial and Sportfishing (COMM) and Shellfishing Harvesting (SHELL). Beneficial uses designated to protect the aquatic environment and which

indirectly sustain recreation activities include: Warm Freshwater Habitat (WARM), Cold Freshwater Habitat (COLD), Preservation of Areas of Special Biological Interest (ASBS), Wildlife Habitat (WILD), Preservation of Rare and Endangered Species (RARE), Marine Habitat (MAR), Fish Migration (MIGR), Fish Spawning (SPWN) and Freshwater Replenishment (FRSH). These beneficial uses generally pertain to the maintenance of the natural environment that can be enjoyed by nature observers, sportfishers and shellfish harvesters.

Impacts of Programs on Water Quality

Many of the creeks, bays, lagoons and reservoirs manifest impaired uses due to pollution from point source discharges and non-point source discharges. The major focus in the last seven years was on controlling and upgrading point source discharges. Pollution from point sources has now greatly decreased in magnitude while non-point source pollution remains as a troublesome area.

Control of Point Source Discharges--

In 1979, approximately 530 million gallons/day (mgd) of treated municipal sewage and 70 mgd of industrial wastewater were discharged into the San Francisco Bay system. The wastewater facilities Construction Grants program under P.L. 92-500 and the State Water Resources Control Board have made considerable headway towards improving the quality of wastewater entering the Bay. Industrial discharges are also carefully regulated and monitored by the Regional Board and other agencies.

Pollutants removed in municipal treatment processes are primarily coliform bacteria and associated pathogenic organisms, BOD_5 (5-day biochemical oxygen demand), suspended solids, oil and grease and the reduction of ammonia. Industrial treatment often is aimed at pollutants generated by the specific industrial processes, such as BOD_5 from cannery wastes, heavy metals from plating works, oil and grease from machine shops, etc. In general, the conservative elements are nutrients (nitrogen and phosphorus), heavy metals, pesticides and other synthetic and organic chemicals.

For secondary-treated wastewater, which can now be considered the norm in the region, removal of 90-98 percent of the BOD_5 and suspended solids can be anticipated. With this type of impovement in wastewater quality, the following benefits, which indirectly help to improve recreation opportunities, could occur:

(1) Dissolved oxygen concentrations in Bay waters will increase and stabilize with the reduction in organic materials which consumes oxygen in the breakdown process. High levels of dissolved oxygen promote a healthy environment for fisheries and natural processes.

(2) Removal of organic materials improves the aesthetic quality of waters. Purging of discolored waters and putrid odors contributes to the enjoyment of the Bay and shore areas.

(3) Visual water quality in the vicinity of the treatment plant and discharge area improves with the elimination of oil slicks, and floating debris in the treatment process.

(4) Odors in the vicinity of treatment plants are reduced through upgraded levels of treatment and use of anaerobic digestors. Although plants may still not be completely odor-free, presumably the frequency of occurrence and areal extent of detected odors are reduced. This would allow more positive consideration of areas near treatment plants for recreational use.

(5) Removal of suspended sediments helps clean up the zone of turbid water typically associated with the discharge plume of a wastewater outfall. Aside from the aesthetic improvement, the contaminants associated with the suspended sediments are also reduced, leading to a healthier environment than before the cleanup.

(6) In certain projects, relocation of wastewater discharges to receiving waters with better flushing and dispersion characteristics has improved localized water quality and the Bay environment.

(7) Public health aspects of Bay waters have improved with the removal of bacteria and a percentage of the pathogenic organisms in sewage. Control of pathogens from wastewater has reached the level that municipal discharges are considered less of a problem than surface runoff in many areas.

Control of Non-Point Source Discharges--

Wasteloads from non-point sources occur primarily from urban and non-urban runoff over a six-month period from November through April and cause a mesureable impact to watercourses, lakes and reservoirs and ultimately the Bay. Other contributors to non-point sources are seepage from poorly-operating septic systems, uncontrolled littering and dumping, and animal wastes.

Pollution problems attributed to surface runoff are transported sediments and associated pollutants, nutrients from fertilizers and organic materials, oil and grease washed from city streets and BOD5 from animal wastes and ground cover. The relative contribution of BOD5 from non-point sources may amount to as much as 30 percent of the total load on receiving waters in 1985. However, sediments are the biggest problem, exceeding the other parameters by nearly an order of magnitude.

The greatest source of surface runoff is erosion from poor land management and washoff from residential, commercial and industrial areas. Newly-graded construction sites and unpaved roads are the most flagrant problem areas.

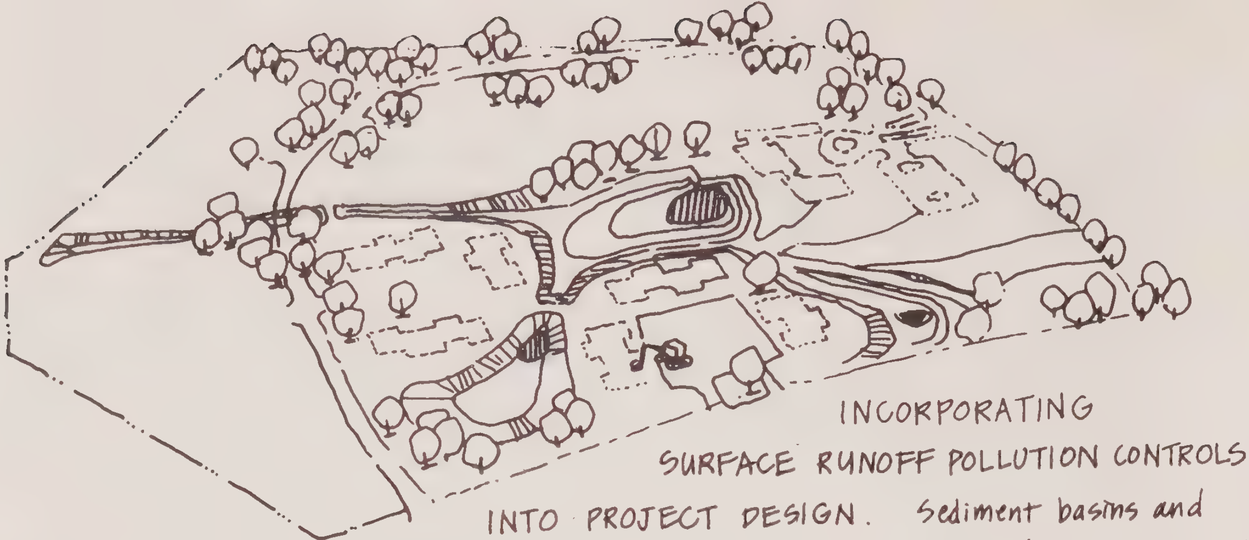
In the past, control of non-point source discharges was intermittent and not consistently applied to all areas. Control measures are generally regulated by individual cities and counties and vary by area. Section 208--areawide non-point source pollution control--under P.L. 92-500 brought this situation to the forefront. Under the aegis of the designated agency for Section 208 planning, non-point source controls are now being coordinated on the county level and regionwide.

The initial county surface runoff plans contain recommendations designed to reduce pollution in stormwater runoff. The major recommendations which might directly lead to water quality improvement include measures to:

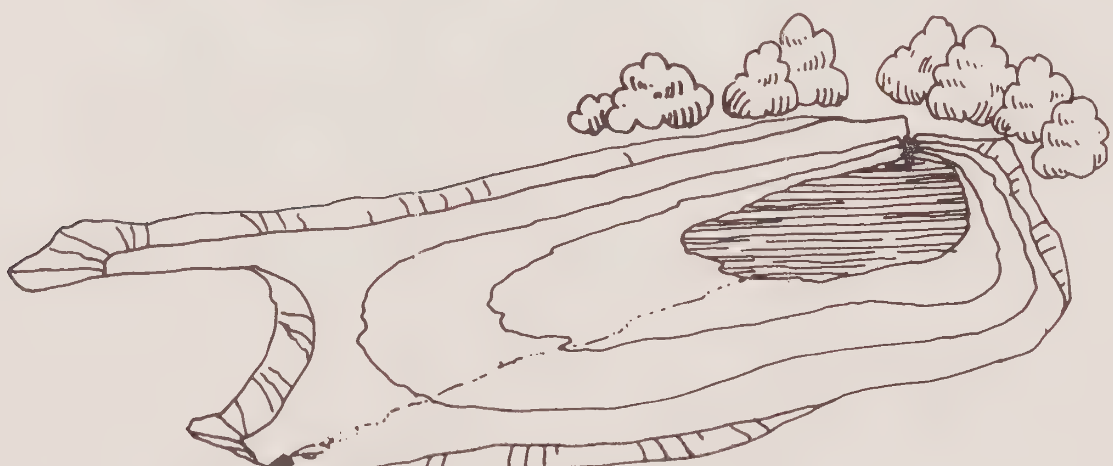
- o Improve erosion controls
- o Improve street sweeping
- o Improve catch basin and storm drain cleaning
- o Improve littering and dumping controls
- o Establish watercourse protection measures, including buffer strip requirements or setbacks
- o Establish performance standards for development in water supply watersheds
- o Control animal wastes

The first five of the above measures are designed to reduce pollutants in surface runoff and thus lead to cleaner streams and lakes. The control measures recommended in the initial county plans are intended to be applied countywide. Thus, water quality improvements throughout the region can be expected to result from their implementation. Individual water bodies are not singled out for special attention in these plans. However, the 1979/80 Surface Runoff Workplan, which continued to update the County plans, will focus on improving the quality of selected water bodies. The following examples illustrate how the recommended control measures can increase open space and recreational opportunities.

Erosion Controls--More effective erosion controls will reduce sediment loads in streams. This will result in lower turbidity of surface waters and less sediment deposition in lakes and reservoirs. Reduction in turbidity and bottom sediments will permit greater recreational usage of the region's water bodies. For example, Lake Temescal in Alameda County is identified in the Basin Plan as an important surface water with water contact recreation as one of its designated beneficial uses. Swimming in this lake has been prohibited because of quicksand-like deposits of deep soft mud at its bottom. The mud is caused by upstream erosion.



INCORPORATING SURFACE RUNOFF POLLUTION CONTROLS INTO PROJECT DESIGN. Sediment basins and interceptor/drainage channels can be designed as an integral part of a project. When construction has been completed, the basins and channels can be converted into ponds and water-courses which enhance the project environment.



PERMANENT SEDIMENT BASINS

Large sediment basins within a residential subdivision can control sediment in the winter and serve as recreation and open space areas during the summer dry season.

Reduction in turbidity will improve visual enjoyment of surface waters and will enhance fishing opportunities by allowing greater productivity and diversity of fish species.

Other types of erosion control plans during housing construction, such as setting aside a parcel(s) for use as a receiving sediment basin could be used. Not only is surface runoff cleaner, but the sediment basin filled with topsoil and nutrients could be converted into a park and satisfy both recreation and open space needs.

<u>Street Sweeping, Catch Basin Cleaning, Littering and Dumping Controls</u>--These control measures can be expected to improve water quality for recreational benefit by reducing:

- Oil and grease film on surface waters

- Floatables (floating litter and debris in streams and along shorelines of lakes and Bay)

- Toxic chemicals and bacteria

Since these control measures are aimed primarily at urban areas, the expected increase in recreational opportunities will occur primarily in urban lakes and in streams in urban areas. An example of where this measure would result in improved water quality is Lake Merritt (Oakland).

<u>Watercourse Protection</u>--Riparian corridors throughout the region have become repositories for trash and litter. Abuse of streambanks has lead to accelerated erosion rates. These problems have adversely affected beneficial uses of virtually all streams in the urbanized portions of the Bay Area.

The watercourse protection measures should enhance open space and recreational opportunities by:

- Restoring visual amenities to stream corridors

- Increasing public access to streams through preservation of stream buffer strips

- Improving visual enjoyment of streams (reduction in oil, grease, litter, debris and sediment)

- Encouraging public acquisition of stream corridors

Eroded soils and animal wastes contain high concentrations of nitrogen and phosphorus compounds. These compounds are important plant nutrients when stormwater runoff carries these nutrients into lakes and lagoons, algal growth is promoted. When the algae dies it decays, producing nuisance odors. These problems have been observed in Bay Area water bodies. The San Mateo Lagoon and Lake Merritt are examples of places where these problems have occurred.

Reduced soil erosion, control of animal droppings, litter control and improved street sweeping should reduce the transport of nutrients to receiving waters. Thus, reductions in algal growths and nuisance odors can be expected.

Watercourse Protection ordinances can delimit buffer strips along streams, require construction of auxiliary sediment basins near streams and other measures. These serve to protect water quality and also perpetuate permanent open space areas near watercourses and water bodies.

V. IMPLEMENTATION AND EVALUATION OF RECREATION AND OPEN SPACE OPPORTUNITIES

Opportunities for restoring and enhancing recreation and open space resources through water quality management programs exist in many areas. Tables 1 and 2 summarize the potential open space, access and recreation opportunities of water quality treatment and surface runoff management facilities. The realization of these benefits occurs through careful planning evaluation and selection of projects for maximum benefits in targeted areas, interagency agreements where appropriate, and sufficient funding to carry out and maintain the benefits.

Technical Memorandum No. 56 - "Economic Assessment of Recreational Benefits from Water Pollution Control Programs" evaluates and develops methods for assessing costs and recreational values to assist local decision-makers in maximizing the potential benefits of these facilities.

TABLE 1. POTENTIAL OPEN SPACE, ACCESS AND RECREATION OPPORTUNITIES OF WASTEWATER FACILITIES

Potential Opportunities: ● Good; ○ Conditional

TYPE OF FACILITY	OPEN SPACE				PUBLIC ACCESS					RECREATION											
	Aesthetics	Resource preservation	Maintain low-intensity land uses	Preserve regional integrity	Bay Shoreline	Streams & Lakes	Recreation areas	Scenic areas	Natural resource areas	Swimming	Boating	Fishing	Clam harvesting	Aquaculture for reacreation harvest	Hunting	Nature/wildlife observation	Picknicking, camping	Hiking, jogging, biking	Parks, golf courses, gardens	Meeting area and educational use	Organized group (base-ball, tennis, etc.)
WASTEWATER TREATMENT FACILITIES																					
Conversion of obsolete facilities																					
Buildings																				●	
Lagoons, basins, etc.																			●		●
Control building/laboratory																				●	
Settling basin(s)																					○
Treatment/polishing lagoons	○		●								○	○		●		○					
Land-based treatment/disposal																					
Infiltration/percolation basins	○		●													○					
Forest or meadow application	●	●	●	●											●	●			●		
Marsh/wetland treatment	●	●	●	●											●	●					
Agricultural application	●	●	●	●											○						
FACILITIES SITES & EASEMENTS																					
Unused waterfront areas	●	●	●		●			●	●				●		●						
Unused grounds at site area		●	●												●	●		●			●
Facility access roads					●	●	●	●	●								●				
Pipeline right-of-ways					●	●	●	●	●								●				
RECLAIMED WASTEWATER																					
Agricultural irrigation	●	●	●	●																	
Landscape irrigation	●	●	●	●															●		●
Aquatic system augmentation or creation:																					
Lakes, ponds	●	●	●	●						●	●	●		●	●	●					
Marshes, wetlands	●	●	●	●											●	●					
	●	●	●	●						●	●	●		●	●	●					

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TABLE 2. POTENTIAL OPEN SPACE, ACCESS AND RECREATION OPPORTUNITIES OF SURFACE RUNOFF MANAGEMENT FACILITIES

Potential Opportunities

● Good

○ Conditional

TYPE OF FACILITY	OPEN SPACE				PUBLIC ACCESS					RECREATION											
	Aesthetics	Resource preservation	Maintain low-intensity land uses	Preserve regional integrity	Bay Shoreline	Streams & Lakes	Recreation areas	Scenic areas	Natural resource areas	Swimming	Boating	Fishing	Clam harvesting	Aquaculture for reacreation harvest	Hunting	Nature/wildlife observation	Picknicking, camping	Hiking, jogging, biking	Parks, golf courses, gardens	Meeting area and educational use	Organized group (base-ball, tennis, etc.)
STORMWATER MANAGEMENT																					
Runoff Storage lagoons																					
Dentention/flood basins																					
o lined			●	●							○										
o unlined/vegetated	●		●	●							○				●	●			●		
Infiltration/groundwater recharge system																					
Sediment basins			○																		
o wet season											○					○					
o dry season																			●		●
STREAM CHANNEL MANAGEMENT																					
In-Channel storage & control (small dams, enlarged channels, etc.)		○								○		○				○					
Side channel storage & control (spillways, floodways, etc.)	○		○	○							○							○*	○*		○*
Off channel storage	○		○	○							○							○*	○*		○*
Stteamside buffer strips	●	●	●	●		●	●	●	●												
Stream conservation zones	●	●	●	●		●	●	●	●												
OTHER MANAGEMENT																					
Runoff treatment systems																					
o Marshes, wetlands	●	●	●	●	○			○	●						●	●					
o Ponds, lagoons	●	●	●	●		○		○	●			●		●		●					

* Dry season

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Table 1: Existing and Potential Beneficial Uses of Surface Waters

	SURFACE WATERS	MUN	AGR	IND	PROC	GWR	FRSH	NAV	POW	REC1	REC2	COMM	WARM	COLD	ASBS	SAL	WILD	RARE	MAR	MIGR	SPWN	SHELL
1	Merced Lake	○									●			●			●					
2	Crystal Springs Lakes	●									●		●	●	○		●	●				
3	San Mateo Creek						●			○	○			○			●	●				
4	Pilarcitos Lake	●									○			●	○		●	●				
5	Pilarcitos Creek	●	●							○	○			●			●	●		●	●	
6	San Andreas Lake	●									●		●	●	○		●	●				
7	San Vicente Creek		●							○	○			●			●	●		●	●	
8	Denniston Creek		●							●	●		●	●			●	●		●	●	
9	Frenchmans Creek		●							●	●			●			●	●		●	●	
10	Purisima Creek		●							●	●			●			●	●		●	●	
11	Lobitas Creek		●							●	●			●	○		●	●		●	●	
12	Tunitas Creek		●							○	○			●	○		●	●		●	●	
13	San Gregorio Creek		●							●	●		●	●			●	●		●	●	
14	Pescadero Creek		●							●	●			●	○		●	●		●	●	
15	Searsville Lake		●							●	●		●	●			●					
16	Felt Lake		●							●	●		●				●					
17	San Francisquito Creek									○	○		●	●			●			●	●	
18	Stevens Creek Reservoir	●				●					●		●	●			●			●	●	
19	Stevens Creek						●			●	●		●	●			●			●	○	
20	Calero Reservoir	●				●				●	●		●				●					
21	Almaden Reservoir	●				●				●	●		●				●					
22	Guadalupe Reservoir	●				●				○	○		●				●					
23	Lake Elsman	●									○			●			●					
24	Campbell Percolation Ponds					●							●	●			●					
25	Lexington Reservoir	●								●	●		●	●			●					
26	Vasona Reservoir					●				●	●		●	●			●					
27	Cotton Wood Lake									●	●		●	●			●					
28	Los Gatos Creek	●				●	●				○			●			●			○	○	
29	Sandy Wool Lake										●		●	●			●					
30	Guadalupe River									○	●		●				●			○	○	
31	San Felipe Creek									○	○		●	○			●					
32	Coyote Reservoir	●	●							○	○		●	●			●					
33	Anderson Reservoir	●				●				●	●		●	●			●					
34	Cherry Flat Reservoir	●	●							○	○		●				●				●	
35	Coyote Creek									○	●		●	●			●	●		●	●	
36	Arroyo De La Laguna[1]					●				●	●		○	○			●			●	●	
37	Shadow Cliffs Reservoir									●	●		●	●			●					
38	Arroyo Del Valle[1]	●				●				○	○			●			●			○		
39	Del Valle Reservoir	●								●	●		●	●			●					
40	Alameda Creek		●			●				●	●		●	●			●			○	○	
41	Elizabeth Lake										●		●	●			●					
42	Arroyo Hondo[1]	●					●			●	●		●	●			●				●	
43	Calaveras Reservoir	●									○		●	○			●					
44	San Antonio Reservoir	●									○		●	●			●					
45	Cull Canyon Reservoir									●	●		●	○			●					
46	San Lorenzo Creek[1]									●	●		●	●			●			●	●	
47	San Leandro Reservoir	●									○		●	●			●					
48	Lake Chabot	●									●		●	●			●					
49	San Leandro Creek						●			○	○		○	●			●			○	○	
50	Lake Temescal									●	●		●				●					
51	Lake Merritt									●	●		●	●			●					
52	Briones Reservoir	●								○	○		●	○			●					
53	San Pablo Reservoir	●								●	●		●	●			●					
54	Lafayette Reservoir	●								●	●		●	●			●					
55	Pinole Creek									○	○		●	●			●			●	●	
56	Walnut Creek[1]									○	○		●	●			●					
57	Mallard Reservoir[2]	●	●	●	●						○		●				●					
58	Marsh Creek									○	○		●				●	●				
59	Marsh Creek Reservoir									○	○		●				●	●				
60	Contra Loma Reservoir[2]	●	●	●	●						●		●	●			●					
61	Lake Curry	●									○		●				●					
62	Lake Madigan	●	●								●		●	●			●					

Table 1. Existing and potential Beneficial Uses of Surface Waters (continued)

	SURFACE WATERS	MUN	AGR	IND	PROC	GWR	FRSH	NAV	POW	REC 1	REC 2	COMM	WARM	COLD	ASBS	SAL	WILD	RARE	MAR	MIGR	SPWN	SHELL
63	Lake Frey	●									●		●				●					
64	Suisun Creek									○	○		●	●	○		●			●	●	
65	Suisun Slough									●	●		●		○		●					
66	Montezuma Slough									●	●		●		○		●	●				
67	Lake Herman	●									○		●	●			●					
68	Chiles Creek	●					●			○	○		●	●			●					
69	Sage Creek	●					●			○	○		●	●			●					
70	Lake Hennessey	●									●		●	●			●				●	
71	Conn Creek	●					●			●	●			●			●			●	●	
72	Rector Reservoir	●									●		●	●			●					
73	Milliken Reservoir	●									○		●				●					
74	Lake Marie	●	●							○	○		○				●					
75	Lake Chabot	●	●							●	●		●	●			●					
76	Dry Creek	●	●							●	●			●	○		●			●	●	
77	York Creek									○	○			●			●			●	●	
78	Napa River	●	●					●		●	●		●	●	○		●	●		●	●	
79	Sonoma Creek									●	●		●	●	○		●	●		●	●	
80	Petaluma River							●		●	●		●	●	○		●	●		●	●	
81	San Antonio Creek									○	○		●	●	○		●			○	○	
82	Stafford Lake	●									●		●	○			●					
83	Novato Creek	●								○	○		○	○			●			○	○	
84	Rodeo Lagoon									●	●			●			●					
85	Miller Creek									○	○		●	●			●	●		○	○	
86	Lake Lagunitas	●									●		●	●			●					
87	Bon Tempe Lake	●									●		●	●			●					
88	Alpine Lake	●									●		●	●			●					
89	Kent Lake	●									●		●	●			●					
90	Lagunitas Creek									●	●			●	○		●	●		●	●	
91	Phoenix Lake	●									○		●	●			●					
92	Nicasio Creek	●					●			●	●			●			●			●	●	
93	Nicasio Reservoir	●					●				○		●				●					
94	Olema Creek									●	●			●			●			●	●	
95	Walker Creek									○	○			●	○		●	●		●	●	
96	Crystal Lake									○	○		●				●					
97	Pacific Ocean			●				●		●	●	●			●		●	●	●	●	●	●
98	South Bay			●				●		●	●	●			●		●	●	●	●	○	●
99	Lower Bay			●				●		●	●	●			○		●	●	●	●	○	●
100	Central Bay			●	●			●		●	●	●			○		●	●	●	●	●	●
101	San Pablo Bay			●				●		●	●	●			○		●	●	●	●	●	●
102	Suisun Bay & Lower San Joaquin			●	●			●		●	●	●			○		●	●	●	●	●	
103	Delta			●	●			●		●	●	●	●		○		●	●		●	●	
104	Bolinas Lagoon									●	●	●			●		●	●	●	●	●	●
105	Drakes Estero									●	●	●			●		●	●	●		●	●
106	Limantour Estero									●	●	●			●		●	●	●		●	●
107	Tomales Bay									●	●	●			●		●	●	●	●	●	●
108	San Pedro Creek										●		●	●			●			●	●	
109	Pomponio Creek		●							○	●			●			●			●	●	
110	Corte Madera Creek									○	●			●			●	●				
111	Old Mill Creek										●			●			●					
112	Pine Gulch Creek	●									●			●			●			●	●	
113	Kimball Reservoir	●									○		●				●					

NOTES:

1. Includes Upstream Tributaries.
2. Offstream Reservoir

○ Potential Beneficial Use.

● Existing Beneficial Use.

Municipal and Domestic Supply (MUN) — Includes usual uses in community or military water systems and domestic uses from individual water systems.

Agricultural Supply (AGR) — Includes crops, orchard and pasture irrigation, stock watering, support of vegetation for range grazing and all uses in support of farming and ranching operations.

Industrial Process Supply (PROC) — Includes process water supply and all uses related to the manufacturing of products.

Industrial Service Supply (IND) — Includes uses that do not depend primarily on water quality such as mining, cooling water supply, hydraulic conveyance, gravel washing, fire protection, and oil well repressurization.

Groundwater Recharge (GWR) — Natural or artificial recharge for future extraction for beneficial uses and to maintain salt balance or halt salt water intrusion into freshwater aquifers.

Freshwater Replenishment (FRSH) — Provides a source of freshwater for replenishment of inland lakes and streams of varying salinities.

Navigation (NAV) — Includes commercial and naval shipping.

Hydropower Generation (POW) — Used for hydropower generation.

Water Contact Recreation (REC-1) — Includes all recreational uses involving actual body contact with water, such as swimming, wading, water skiing, skin diving, surfing, sport fishing, uses in therapeutic spas, and other uses where ingestion of water is reasonably possible.

Non-Contact Water Recreation (REC-2) — recreational uses that involve the presence of water but do not require contact with water, such as picnicking, sunbathing, hiking, beachcombing, camping, pleasure boating, tidepool and marine life study, hunting and aesthetic enjoyment in conjunction with the above activities as well as sightseeing.

Ocean Commercial and Sport Fishing (COMM) — The commercial collection of various types of fish and shellfish, including those taken for bait purposes, and sport fishing in oceans, bays, estuaries and similar nonfreshwater areas.

Warm Freshwater Habitat (WARM) — Provides a warm water habitat to sustain aquatic resources associated with a warm water environment.

Cold Freshwater Habitat (COLD) — Provides a cold water habitat to sustain aquatic resources associated with a cold water environment.

Preservation of Areas of Special Biological Significance (ASBS) — Areas of special biological significance are those areas designated by the State Water Resources Control Board as requiring protection of species or biological communities to the extent that alteration of natural water quality does not occur.

Saline Water Habitat (SAL) — Provides an inland saline water habitat for aquatic life resources. Soda Lake in the Central Coastal Basin is a saline habitat typical of desert lakes in inland sinks.

Wildlife Habitat (WILD) — Provides a water supply and vegetative habitat for the maintenance of wildlife.

Preservation of Rare and Endangered Species (RARE) — Provides an aquatic habitat necessary, at least in part, for the survival of certain species established as being rare and endangered species.

Marine Habitat (MAR) — Provides for the preservation of the marine ecosystem including the propagation and sustenance of fish, shellfish, marine mammals, waterfowl and vegetation such as kelp.

Fish Migration (MIGR) — Provides a migration route and temporary aquatic environment for anadromous or other fish species.

Fish Spawning (SPWN) — Provides a high quality aquatic habitat especially suitable for fish spawning.

Shellfish Harvesting (SHELL) — The collection of shellfish such as clams, oysters, abalone, shrimp, crab and lobster for either commercial or sport purposes.

WQ Tech Memo. No. 40
Peter Russell
David Blois

WATER QUALITY MANAGEMENT PLAN

THE INFLUENCE OF STREET SURFACE TYPE AND CONDITION ON STREET SOLIDS LOADING RATE AND COMPOSITION

Technical Memorandum No. 40
December 18, 1979
January 9, 1980
Revised September 19, 1980

INTRODUCTION

This technical memorandum presents the results of statistical analyses run on street surface solids data obtained from current technical literature. Four principal data sources were utilized: a compilation of earlier published street solids data (Amy et al., 1974), a recent San Jose study (Pitt, 1979), data from the first annual report of a current Castro Valley study (Shawley and Pitt, 1979) and a Caltrans study of highways throughout California (Howell, 1978). Some variables were not reported in each study and sometimes the units of measurement varied. Nevertheless, a consistent and uniform data base was developed upon which the statistical analyses could be performed. A total of 157 distinct reports from the four studies were used.

The object of the analyses was to determine if street solids accumulation rates is influenced by either the condition of the street surface or its type (whether it is made of asphalt or concrete). The influence, if any, of street surface type and condition on the accumulation rates of key components of street solids was also sought in the analyses. The results of this study are needed to formulate best management practices in the control of urban runoff pollution arising from street surfaces.

The statistical analyses are not able to establish a cause and effect relationship even when street surface type or condition makes a significant difference in the accumulation rate of street solids. To help explain the significant relationships we found, we reviewed related technical publications and contacted professionals in the field. Several earlier studies found many of the same relationships that we did, but we were unable to locate any earlier work that attempted to explain why the relationships exist. Previous research has been directed toward related issues such as the influence of land use, traffic density or street cleaning practices. The reasons for the relationships, that were suggested by the professionals, are described in the Discussion section of this Technical Memorandum.

SUMMARY AND CONCLUSIONS

1. A data set consisting of 157 reports of street solids accumulation rates for streets and highways was examined by analysis of variance. The factors used in the analyses to explain the observed variability in loading rates are street surface type (asphalt or concrete), street surface condition, average daily traffic, average traffic speed, adjacent land use, season, and region of the country.

2. After adjustment for all other factors except surface type, the solids accumulation rate of asphalt streets is significantly higher than of concrete streets ($p=.005$). In the Southwestern U.S. the rates are 28 and 11 lb/curb-mi./day, respectively.

3. Asphalt streets accumulate, as street solids, the heavy metals cadmium, chromium, copper and lead at significantly higher rates than do concrete streets: 2 to 3 times as rapidly ($p \leq .050$).

4. The rates of accumulation for BOD, COD, orthophosphate, nitrate, organic nitrogen, iron, manganese, nickel, strontium and zinc are not significantly different between types of street paving material.

5. The condition of the street surface does not significantly correlate with the accumulation rate of any street solids components examined.

METHODS

Analysis of variance was used in this study to determine the influence of potentially important factors on street solids loading rate and composition. These factors, known as independent variables, are street surface type, street surface condition, average daily traffic, average traffic speed, land use, climate and season. One or more of these independent variables can be used to examine the pattern of variability in the street solids data by analysis of variance. Of course, only street surface type and condition are of immediate concern here, but the other factors were studied simultaneously to extract their influence on the scatter in the data, thus elucidating the influence stemming solely from the factors of interest. Too little data was found in the literature to allow testing all of the factors in one analysis so various combinations of factors were alternatively studied. These combinations of independent variables used in such analyses are called models. The models that best accounted for the patterns of variability in street solids accumulation rate were used to estimate the influence of street surface type and/or condition.

A total of 445 analyses of variance were performed. The dependent variables examined were total solids accumulation rate and the accumulation rate of key components of the solids: biochemical oxygen demand (BOD), chemical oxygen demand (COD), orthophosphate, nitrate, organic nitrogen, cadmium, chromium, copper, iron, lead, manganese, nickel, strontium and zinc. Each of the fifteen dependent variables was examined by up to 28 models. The 28 models used are given on Table 1. Some of the dependent variables could not be analyzed by all 28 models due to missing values in some of the 157 reports.

TABLE 1. Description of Models Examined

Model No.	Independent Variables
1	street surface type
1A	street surface type and traffic speed
2	street surface condition
2A	street surface condition and traffic speed
3	street surface type and condition
3A	street surface type, condition and traffic speed
4	street surface type, condition and average daily traffic
4A	street surface type, condition, average daily traffic, and traffic speed
5	street surface type, condition and land use
5A	street surface type, condition, land use and traffic speed
6	street surface type, condition, land use, average daily traffic
6A	street surface type, condition, land use, average daily traffic and traffic speed
7	climate, season and street surface type
7A	climate, season, street surface type and traffic speed
8	climate, season, average daily traffic and street surface type
8A	climate, season, average daily traffic, street surface type and traffic speed
9	climate, season and street surface condition
9A	climate, season, street surface condition and traffic speed
10	climate, season, average daily traffic and street surface condition
10A	climate, season, average daily traffic, street surface condition and traffic speed
11	climate, land use and street surface type
11A	climate, land use, street surface type and traffic speed
12	climate, land use, average daily traffic and street surface type
12A	climate, land use, average daily traffic, street surface type and traffic speed
13	climate, land use and street surface condition
13A	climate, land use, street surface condition and traffic speed
14	climate, land use, average daily traffic and street surface condition
14A	climate, land use, average daily traffic, street surface condition and traffic speed

The dependent variable data were converted by logarithmic transformation before use in the analyses of variance. This data manipulation is frequently employed to reduce the scatter in a data set and to more closely approximate a normal distribution (Berwick et al., 1978; Yücel, 1980). Without exception, the distributions of the log transformed dependent variables were closer to the normal distribution than of the untransformed variables. Most statistical inferences require that the error term in the variance of a variable be normally distributed.

The results of the statistical analyses are of two types. Firstly, statistical significance is determined for the model as a whole and for each independent variable in the model. The format for the significance value is: "p = value". Statistical significance states the probability that subsets of the data formed by the categories of the independent variables are not really different from each other. In other words, it gives the probability that all of the data comes from the same homogeneous population and that any differences arise through sampling fluctuation and measurement error. The closer the significance value is to one, the more likely that there are no real differences between the categories of the independent variables. The closer the significance value is to zero, the greater the probability that the independent variables do separate the data into distinct categories having different average values for the dependent variable. For example, a significance of .5 means there is a fifty-fifty chance that the factor influences the value of the dependent variable; a significance of .1 means there is a one in ten chance that the differences between the categories of the independent variable are due to chance (sampling and measurement error); a significance of .01 means there is only a one in a hundred chance the independent variable has no influence.

The second type of information produced by the statistical analyses is a prediction of the value of the dependent variable for each category of the independent variables in the model. There are two categories for street surface type--asphalt and concrete; and four categories for street surface condition--excellent, good, fair and poor. The amount of confidence one may place in these predictions is expressed by the statistical significance value.

RESULTS

The analyses of variance show that the street paving material is a significant factor in the accumulation rate of total solids and of several heavy metals on street surfaces. Street surface condition, on the other hand, was never found to be a significant factor in the accumulation rates of total solids or of any of the solids constituents examined.

Table 2 presents the significant relationships found in this study. Often several models "explained" a significant amount of the variance in the dependent variable, but only the model "explaining" the greatest amount of variance is shown on Table 2. The model numbers given in the column headed "Best Model" refer to the model descriptions given in

TABLE 2. The Effect of Paving Material Type on the Accumulation Rate of Street Solids in Southwestern U. S.

PARAMETER	BEST MODEL	MODEL R^2	SIGNIFICANCE OF SURFACE TYPE	ACCUMULATION RATE [a]		
				ASPHALT	CONCRETE	RATIO
Total Solids	12	.50	.005	28	11	2.4
Chromium	12	.50	.016	.0065	.0022	2.9
Copper	12A	.50	.022	.0025	.00089	2.8
Lead	8	.29	.036	.067	.022	3.0
Cadmium	7	.40	.050	.00011	.000047	2.3

a. The accumulation rates for asphalt and concrete are given as lb/curb-mi./day. The ratios of the rates are dimensionless.

Table 1. Each of the "Best Models" identified in Table 2 was highly significant in explaining the variability of the street solids parameter ($p < .001$). "Significance of Surface Type" gives the statistical significance of the surface type factor alone. As a rule of thumb, a statistical probability of less than .050 may be considered significant and of less than .010, very significant. Only the street solids components for which the significance of street surface type was at least one chance out of twenty ($p = .050$) were presented on Table 2. The "Model R^2" column of Table 2 lists the fraction of the variability of the dependent variable that is explained by the indicated model (the best model).

The far right column on Table 2 gives the ratio of the accumulation rate on asphalt streets to the accumulation rate on concrete streets. These ratios were computed after eliminating the confounding influence of the other factors in the best model. Thus, these ratios should be interpreted to mean for example: all things being equal except the type of paving material, asphalt streets accumulate lead on the street surface three times as rapidly as do concrete streets. As a further illustration: all other things being equal, asphalt streets accumulate solids at the rate of 27.5 lb/curb-mi/day while the rate for concrete streets is 11.5 lb/curb-mi/day. The ratio of these two rates is 2.4. Beside the ratios on Table 2 are the expected accumulation rates for streets in the Southwestern U.S. paved with either of the two materials. These rates are in lb/curb-mi/day.

For the remaining street solids components examined, BOD, COD orthophosphate, nitrate, organic nitrogen, iron, manganese, strontium, and zinc, the difference between accumulation rates on the two types of street paving materials was not significant at the .050 level.

DISCUSSION

The analysis results, while unambigious and internally consistent, were not wholly expected. However, several related studies, conducted by others, showed results consistent with this analysis. In a study for the U.S. Environmental Protection Agency, Sartor and Boyd (1972) found that "...asphalt streets had loadings 80 percent heavier than all concrete streets. Streets paved partially with asphalt and partially with concrete were intermediate (their loadings were about 65 percent heavier than for all concrete streets)." They suggest that "when the material for paving is being selected, it is recommended that this difference in asphalt and concrete be taken into consideration, along with the factors normally included in such decisions."

In another U.S.E.P.A. sponsored study, Amy et al. (1974) found that concrete paved surfaces had lower total solids loading rates and lower solids content of chromium, lead, nickel, and zinc than did asphalt surfaces. On the other hand, asphalt streets had lower solids content of BOD, orthophosphate, and organic nitrogen. There was no significant difference between the two pavement types for solids content of COD, nitrates, cadmium, copper, iron, manganese and strontium. Much of Amy's group's data was used in the analyses conducted for this Technical Memorandum. Although the statistical procedures were not the same in both instances, the agreement of the conclusions in these two studies is not surprising. Data from a 1976 Texas study (Weland and Malina, 1976) showed similar results when pollutant loadings from asphalt and concrete surfaced highways

were compared. Loadings for COD, total organic carbon, lead, and zinc were higher for the asphalt paved highway.

It is unlikely that any single causitive factor can account for the results of these analyses. Differences in the surface textures of asphalt and concrete pavements may be a major factor. It is possible that asphalt pavements may often have coarser surface textures than concrete pavements and thus provide more surface irregularities in which pollutants can accumulate.

In his San Jose study,Pitt (1979) recognized the importance of street surface texture in retaining solids. He compared several sites having asphalt pavement and noted that "...accumulation rates in the oil and screens test area are about the same or slightly smaller than for any of the other test areas, yet the oil and screens test area always had the greatest street surface loadings observed. Because of the increased surface roughness and generally larger particle sizes in the oil and screens test area, a large quantity of loose material could stay on the street surface and not be removed significantly by rainfall."

A number of national authorities in the field of street surface pollutants were contacted in an effort to obtain the most qualified hypotheses explaining the findings of this study. Most of these professionals were unable to give definitive reasons for the analysis results, however, their suggested explanations are as follows:

1. The two pavement types present different wearing surfaces. The erosion of materials from these surface types by air or water currents probably differs. (Howell, 1980)

2. Maintenance practices for the two pavement types differ. Screenings and a seal coat may be applied to asphalt surfaces every few years. Degradation rates for the surface materials differ. Leaks and spills of fuels, lubricants and hydraulic fluids hasten degradation of asphaltic pavements. (Sartor, 1980)

3. Asphalt surfaces are softened in hot weather. During hot, dry spells, pollutants may be retained on asphalt surfaces and are later washed off by an intense rainfall. Concrete pavements would not exhibit this behavior. (Gupta, 1980)

4. As the seal applied to asphalt surfaces breaks down, more openings appear in which solids may be trapped. (Racin, 1980)

5. The pores on concrete surfaces may be effectively deeper than on on asphalt surfaces. Thus, the particulates may migrate down through the pavement and not be sampled in accumulation rate studies. (Field, 1980)

6. Factors important in determining the accumulation rate of street solids were not included in the analyses, such as: local soil type, grade, alignment, width of pavement, median conditions, landscaping both in the median and adjacent to the curb, presence

or absence of sprinklers in the median and adjacent to the curb as well as the frequency of operation, age of the facility, type of surface for each material, and unrepresentative sampling in the data base. (Scott, 1980)

While the statistical basis for these analyses is sound, caution should be exercised in interpreting these results. Sample collection and measurement techniques for some parameters varied from study to study. In addition, other site-specific conditions may possibly influence the accumulation rate of pollutants for an area. These factors could not be included in this analysis because of the lack of consistent or specific data. Differences in surface texture within one type of material, in particular, seems likely to influence the rate of street solids accumulation. It was not possible to include the grade of texture within the asphalt or concrete categories, again because of the lack of data. Scientific research with well defined control and test areas is clearly needed to further clarify this phenomenon.

Perhaps the reason no significant effects were found for street surface condition yet numerous street surface type effects were observed lies in the definition of the factor categories. Asphalt versus concrete pavements are readily distinguishable while evaluation of the surface condition is more subjective. If a truly objective measure of street surface condition were available, more resolution of the differences between condition categories might appear.

RECOMMENDATIONS

1. All other things being equal, streets should be paved with concrete rather than asphalt, toward the objective of minimizing solids accumulation. However, if distinct economic or other incentives favor the use of asphalt, choosing concrete as a paving material is not recommended pending resolution of the statistically significant results found here.

2. The findings of this study should be used in developing the next generation of street solids models. Surface type should definitely be included as a model factor. On the other hand, the value of street surface condition in determining solids accumulation rate has yet to be established.

3. Rigorous scientific research both in the laboratory and in the field should be conducted to examine this problem. As a minimum the research should consider the differences in texture that may occur with either paving material.

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WQ/TECH MEMO No. 41
Steven Goldman

WATER QUALITY MANAGEMENT PLAN

REQUIREMENTS FOR EROSION AND SEDIMENT CONTROL PLANS

Technical Memorandum No. 41
December 18, 1979
Revised March 1981

Erosion and sediment control plans are a vital element of a local government's regulatory program. It is much easier for a city or county to assess the adequacy of and enforce a plan than it is to enforce non-pollution on a construction site. The requirements for an erosion and sediment control plan should be included in a grading ordinance or specified in administrative procedures, such as in a BMP manual. The following proposed requirements, after review by the Water Quality Technical Advisory Committee, will be included in the regional BMP specifications manual.

The Erosion and Sediment Control Plan

1. Definition

   An erosion and sediment control plan is a document that specifies how erosion and sediment will be controlled on a construction site in compliance with laws, ordinances, and accepted standards and specifications.

2. Plan Preparer

   The plan shall be prepared and signed by a person or firm qualified by training and experience to have expert knowledge of erosion and sediment control methods.

3. Content

   The plan shall consist of three parts:

   (a) A <u>narrative</u>, containing:

   - a brief description of the overall project;
   - the date grading will begin and the expected date of stabilization;

- o phasing of land-disturbing activities, including removal and stockpiling of topsoil;

- o a brief description of erosion and sediment control measures to be implemented, including both temporary and permanent measures;

  (Note: Measures must meet or exceed all requirements in the Erosion and Sediment Control Ordinance and applicable standards and specifications. If grading is scheduled to be completed before the rainy season begins, the plan should specify contingency actions to winterize the site if construction should fall behind schedule.)

- o a maintenance program, with provisions for frequency of inspection, reseeding of vegetated areas, repair or reconstruction of damaged structures, cleanout method and frequency, disposal of waste materials and disposition of control measures after they have served their purpose (see Sample Erosion and Sediment Control Plan).

(Note): This narrative is intended to summarize for the plan checker the aspects of a project which are important for erosion control. It is not intended to duplicate the requirements of project applications and EIRs. Applicable portions of those documents should be referenced in the narrative.

(b) A <u>map</u> showing:

- o existing topography and site conditions;

- o location of the project relative to highways, municipalities, major streams or other identifiable landmarks;

- o acreage of the project;

- o contours at an interval and scale sufficient for distinguishing runoff patterns prior to and after disturbance;

- o limits of clearing and grading;

- o critical environmental areas within or near the project areas, such as streams, lakes, ponds and wetland areas;

- o nature and extent of existing vegetation;

- o surface area of each soil type and relative erodibility;

- o location and types of both temporary and permanent control measures;

- o dimensional details of facilities (see Figure I.B.1).

(c) Construction drawings or sketches and supporting data, including:

- o key dimensions and other important details (See Figure 3)
- o engineering and design assumptions and calculations (for structural measures)
- o brief analysis of problems posed by storm runoff on downstream areas.

SAMPLE EROSION AND SEDIMENT CONTROL PLAN

Description

The project is a 4,000-square-foot school building with exercise fields on a 6-acre site.

Grading and Erosion Control Schedule

Grading project is scheduled to start on June 15, 1980. Temporary erosion control measures to be fully implemented by October 1, 1980. Permanent control measures to be installed by August 31, 1981.

Sequence of Land-Disturbing Activities

In June and July 1980, the school site and surrounding area will be stripped and the topsoil stockpiled at the southeast corner of the site. This area will then be brought to grade without disturbance to other areas. Construction of sediment basins and diversion dikes will commence thereafter and be completed before October 15, 1980. All areas brought to grade, except the building site, will be seeded with temporary vegetation and mulched by September 15, 1980.

Soil Data

The entire site is Glenelg silt loam, eroded rolling phase; this soil ranges from moderately to severely erodible.

Erosion Control Program

Seed and straw mulch are to be applied to all graded areas, except for building areas, a 30-foot border, streets and parking areas, not later than September 15, 1980. The straw will be anchored by punching with a roller.

Sediment Control Program

Control will be exercised through installation of 1 earth sediment dam of 0.5 acre-foot capacity and a minor sediment basin of 0.15 acre-foot capacity, with 1,500 feet of earth diversions directing storm runoff to the basins.

Maintenance Program

All measures are to be inspected daily by the site superintendent or his representative. Any damaged structural measures will be repaired by the close of the day. Sediment basins are to be cleaned out at 50% trap efficiency level and the material disposed of by spreading on the site. Diversions may be removed after areas above them have been stabilized with grass or mulch. The sediment basin at the south end will not be removed until all other mechanical measures have been removed and the areas stabilized. No controls are to be removed without approval of the site inspector.

Figure 1
(From Public Facilities Manual, Volume 3, Fairfax County, Virginia, 1978)

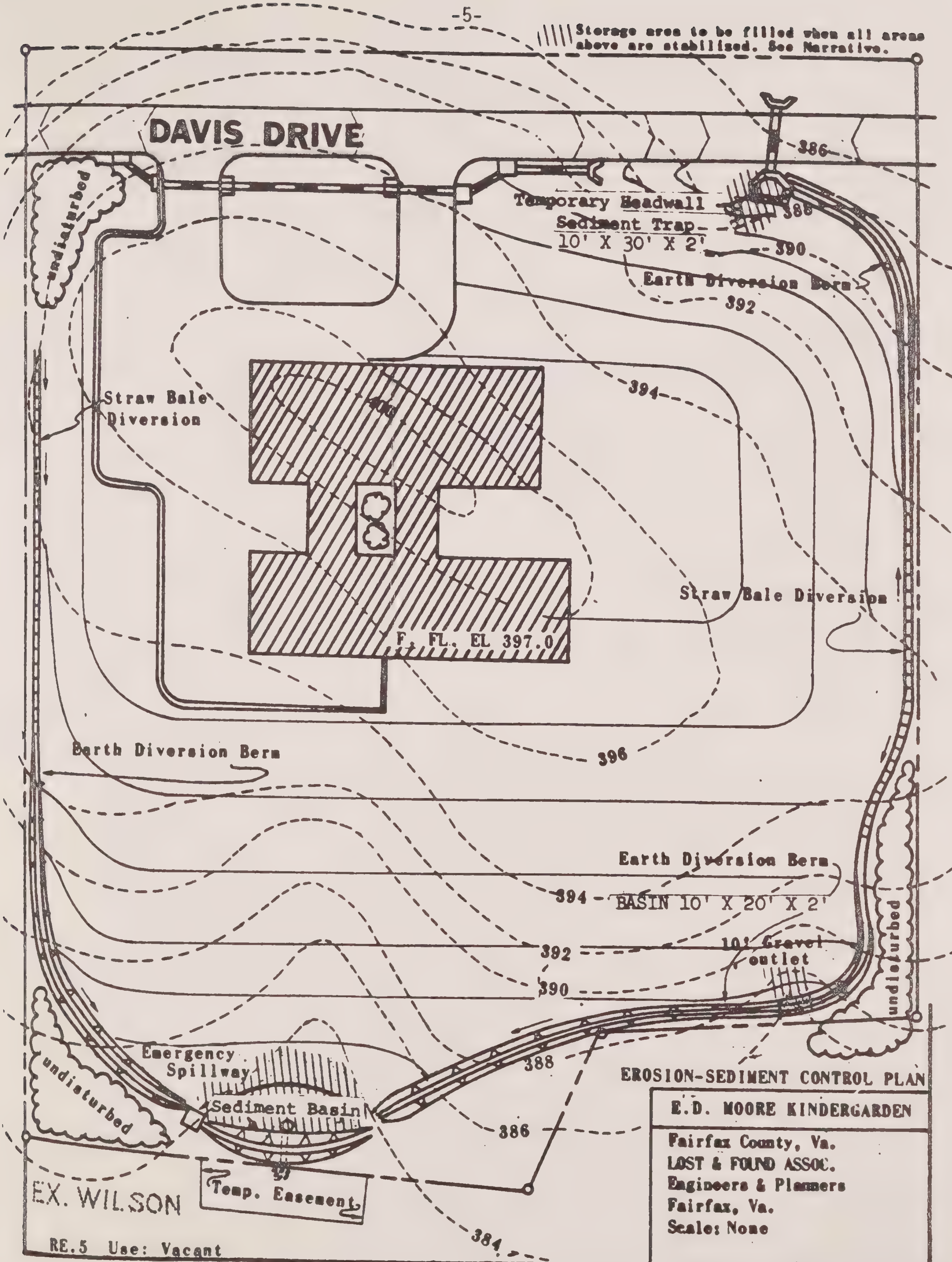

Figure 2. Example map from Erosion and Sediment Control Plan (from Public Facilities Manual, Volume 3, Fairfax County, VA 1978)

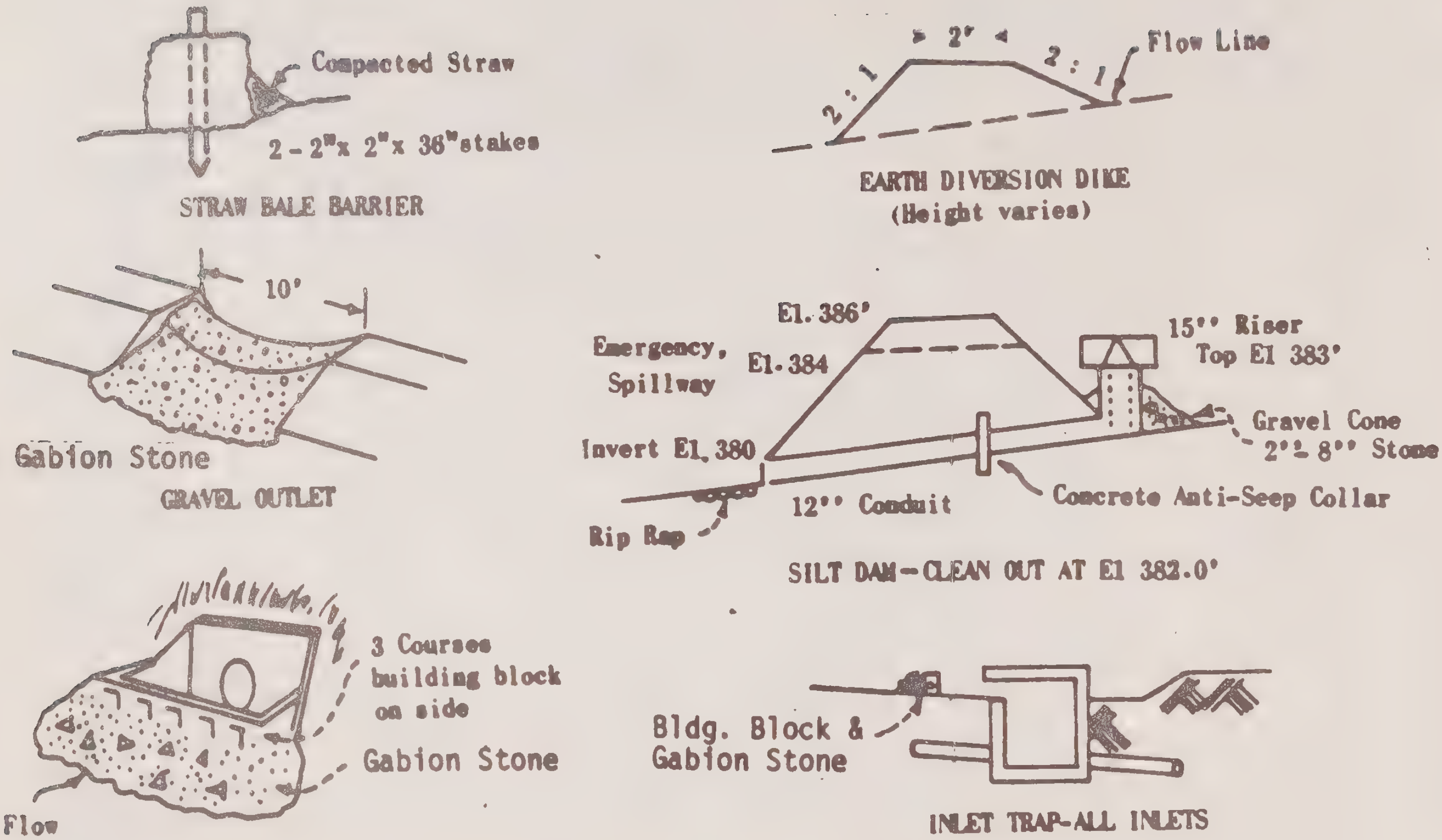

Figure 3. Sample Construction Details

(from Public Facilities Manual, Volume 3, Fairfax County, Virginia, 1978)

WQ Tech Memo No. 43
Steven J. Goldman and
Burgess L. Kay,
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WATER QUALITY MANAGEMENT PLAN

VEGETATION METHODS FOR CONSTRUCTION SITE STABILIZATION

Technical Memorandum No. 43

January 15, 1980

Revised January 2, 1981

A. INTRODUCTION

The purpose of this memorandum is to present an effective method for vegetative stabilization of construction sites in the Bay Area. It is not intended as a comprehensive inventory of all possible techniques. Rather, it is an attempt to highlight, for public works officials, planners and land developers, the important principles and to recommend a simple method which is known to be effective in this area.

Vegetation is an effective erosion and sediment control practice because it retains soil on-site. Thus, the need for construction of permanent sediment basins and for dredging streams, lakes and reservoirs is reduced or eliminated. While the cost of vegetative stabilization is not negligible, it is small compared to the costs of other construction activities (such as road building and land leveling).

Construction activities increase erosion rates from 10-2,000 times above the natural rates. Resulting sediment must be removed year-after-year at a cost of roughly $7/ton. The current annual cost for dredging silt from Bay Area creeks, storm drains, lakes and reservoirs and from San Francisco Bay is about $65 million - $13 per year for each man, woman and child in the Bay Area. Vegetative stabilization can keep sediment yields to within 100% of pre-construction rates. Vegetation also offers both short-term and long-term protection. It should be used during construction if construction is not completed before October 15. Vegetation should always be part of the final plan for a project.

The three major functions of vegetation as an erosion control measure are:

- o to absorb the impact of raindrops
- o to reduce the velocity of runoff
- o to allow precipitation to enter the soil rather than carry soil particles down slope

The most effective means of accomplishing the above functions is the establishment of a continuous vegetative cover. The most continuous cover type is grass. Grass establishes itself quickly and can provide complete erosion protection. After 3-5 years other species (such as native shrubs) may colonize the site and replace the grass. There is no problem when this occurs, as the site is already stable. Planting trees or shrubs is not effective for initial erosion control because not enough of the land surface is protected. In time, however, the deep, strong roots of trees will aid in stabilizing large soil masses. Flowers are more effective than trees or shubs but less effective than grass (see Technical Memorandum No. 61). Besides being slow growing, many flowers are tap-rooted and do not produce a fibrous root mass.

The following criteria were used to evaluate the various vegetation types and methods:

- o erosion control effectiveness
- o commercial availability of materials
- o cost to apply and maintain
- o drought tolerance
- o fire hazard.

It must be noted, however, that vegetative stabilization will only be effective if the site is geologically stable and is engineered properly. Thus, slopes must not be overly steep (greater than 2:1) and diversion devices (such as dikes, ditches and berms) may be required to prevent runoff from crossing a steep or lengthy disturbed slope. Such runoff should be conveyed from the site to reduce soil saturation, a common cause of slope failure.

B. SEEDING

1. Seed Type

The following seed mix is suitable for nearly all sites in the Bay Area:*

Seed Type	lbs/acre	Percent
Blando brome	30	60
Annual rye	20	40

Blando brome is an ideal grass for erosion control. It germinates and grows quickly and does not produce tall growth which may become a fire hazard. If given a small amount of precipitation, it will generate seed for the next year.

Ryegrass is very rapid growing and the seed is inexpensive ($.25/lb for seed compared to $2.50/lb for Blando), making it a very desirable erosion control plant. However, it should not be planted alone for permanent erosion control because it will not persist after the first year. It is a high fertility plant and will not survive without repeated fertilization. It also releases a substance which inhibits the growth of plants. Ryegrass could, however, be used alone in intermediate stages of construction where winter comes before construction is completed and the site will be reshaped next spring, or where permanent landscaping will be applied the following growing season.

Perennial grasses are slower to develop than annual grasses (both of the above species are annuals). Thus, they are not as good for providing first year protection. Because perennials tend to green-up earlier in the fall and remain greener longer into spring, they do offer a better overall appearance. In addition, fire hazard is lower with perennials (see Technical Memorandum No. 61).

Seed Specifications (1)

All seed shall be delivered to the site tagged and labeled in accordance with the California Agricultural Code and shall be acceptable to the County Agricultural Commissioner.

Blando brome and ryegrass seed shall be of a quality which has a minimum pure live seed content of 80% (% purity x % germination) and weed seed shall not exceed 0.5% of the aggregate of pure seed and other material.

* For details on other usable plant materials, see Technical Memorandum No. 61.

2. Time of Planting

The best time to plant is in the fall, just before the rainy season (before September 15). The first rains, which are usually light, will begin the germination process. Germination takes about 4 days following October rainfall. With adequate early season rains and moderate temperatures, the grass cover should provide protection against the heavy winter rains. If the first rain is later, germination will take longer, growth will be slower because of shorter days and colder temperatures, and protection may not be adequate until spring. In addition, the risk of having a heavy rain wash away the seeds is far greater.

Irrigation is not generally necessary, but can be used to ensure adequate growwth before heavy winter rains. If water is added for early germination it should be discontinued when the grass is 2 inches tall. Problems associated with irrigation are:

o high cost (temporary irrigation costs about $1,000/month/acre) (2);

o improper irrigation practices can be harmful, causing excessive loss of seed and soil;

o interrupted irrigation can allow the germinating seed to die. Once irrigation is begun, it should be continued until the grass is 2 inches tall.

Irrigation is an option which:

(1) guarantees early germination and growth even if fall rains are inadequate;

(2) will avoid the necessity for use of other protective measures in December and Janaury if vegetation did not establish under non-irrigated conditions.

Time of Planting Specifications

Seeding, fertilizing and mulching shall be done when construction is completed, but not later than September 15th of any year. If construction is not completed by September 15, temporary structural controls, such as sediment basins, may be used as interim control measures in place of vegetation. However, temporary seeding of annual ryegrass or barley (see Technical Memorandum No. 61) may be desirable to hold soil until construction is begun the next season. Straw mulching should be considered if a plant cover is not obtained by November on either completed or incompleted projects.

3. Seedbed Preparation

Before a site can be seeded, its surface must be roughened or broken up so that it can hold seed and permit germination. Fertilization is also required (discussed in Section 5).

Seedbed Preparation Specifications (1)

The area to be seeded shall have a firm seedbed which has previously been roughened by scarifying, disking, harrowing, chiseling, or otherwise worked to a depth of two to four inches (2" to 4") if slope and soil permit. No implement shall be used that will create an excessive amount of downward movement of soil or clods on sloping areas. Seedbed should be prepared at the time of completion of earth-moving work. Walking a crawler tractor up and down slopes (trackwalking) creates an excellent seedbed.

4. Seed Application

The key factor in seeding is to get the seeds evenly distributed and in contact with the soil. Best results are obtained when seeds are covered with a shallow soil layer. Seed should be covered to a depth of 1/4" - 1/2". Seed should not have a soil cover greater than 1". A seed drill, therefore, provides the best stands of grass. Other seeding methods include broadcast seeding by aircraft or by hand, and hydroseeding. The steepness of slope and size of area determine the proper equipment to use.

Small Areas

Small areas are best hand seeded to provide uniform coverage. Breast seeders (or "belly-grinders") are very inexpensive. Labor is 1-3 hours/acre. Seed can be effectively covered by lightly raking or dragging with a chain. The seed may become covered naturally on a rough, loose seedbed.

Steep Areas

Hydraulic seeding and mulching (hydroseeding) is the most efficient means for seeding steep slopes (typically, slopes greater than 2:1). It is a one-step process for spraying a slurry of seed, fertilizer, wood fiber mulch and water.

The critical factor in hydraulic mulching is the ability of the fiber to adhere to the soil and hold the seed in place during heavy rainfall and wind. This issue is covered in further detail under "Mulching."

A summary of the costs and effectiveness of the various techniques for seed establishment is provided in Table 1.

TABLE 1. SUMMARY OF EROSION CONTROL PRACTICES, THEIR EFFECTIVENESS AND COST

	Treatment	Comments	Effectiveness* Erosion control	Effectiveness* Plant establishment	Approximate cost/acre$**
1.	Seed and fertilizer broadcast on the surface, no soil coverage or mulch.	Inexpensive and fast. Most effective on rough seedbeds with minimum slope and erodibility where seed will cover naturally with soil. Suitable for remote or critical areas where machinery cannot be taken.	1	1-4	250
2.	Seed, fertilizer and 1500 lb/acre wood fiber, applied hydraulically.	Most common hydromulch mix in California. Advantages include holding seed and fertilizer in place on steep and smooth slopes where there may not be an alternative method. Only a minimal mulch effect. Seeds is not covered with soil.	2	3-5	680
3.	Seed and fertilizer broadcast with hydroseeder or by hand. Straw applied with blower at 3,000 lb/acre and tacked.	Common elsewhere in U.S. Very effective as energy absorber and to encourage plant establishment. Straw forms small dams to hold some soil. May be weedy depending on straw source, Not for cut slopes steeper than 2:1. Cost would increase significantly if slopes over 50 feet from access, or application is uphill.	5-7	8-10	880
4.	Seed and fertilizer broadcast with hydroseeder or by hand. Straw broadcast 4,000 lb/acre, rolled to incorporate, another 4,000 lb straw broadcast and rolled again, seeded and fertilized.	Common on difficult fill slopes in California. Very effective. Not possible on most cut slopes. Top of slope access required for rolling.	6-8	8-10	1,200
5.	Roll-out mats (jute, excelsior, etc.). Held in place with wire staples. Seed and fertilizer as in (1).	Some are a good mulch, weed-free, adapted to small areas. Can be installed any season, cuts or fills. Unsightly. Difficult to install on rocky soils. Some are more effective if applied over straw.	5-8	1-10	11,250
6.	Seed, fertilizer and wood fiber applied hydraulically, followed by erosion control chemical such as polyvinyl acetate at 6:1 dilution (6 parts water) at 1,000 lb solid/acre (approx. 200 gal. PVA).	Very expensive, but will hold soil and seed in some very difficult conditions. May restrict penetration of water into soil. Will not cure below 55° F. Not effective on soils which crack. Will not support animal or vehicle traffic. May discourage plant establishment.	10+	1-5	1,570

* 1 = minimal, 10 = excellent
** 1980 contact prices (2)

5. Fertilization

The application of fertilizer is important to the establishment of vegetation, particularly on cut slopes. Blando brome is a low fertility grass. It will survive without the need for reapplication of fertilizer.

Fertilizer Specifications (1)

The fertilizer shall be Ammonium Phosphate Sulfate and contain a minimum of 16% nitrogen, 20% available phosphoric acids, 0% water soluble potash and 15% sulfur uniform in composition, dry and free flowing, pelleted or granular.

All fertilizer shall be delivered in unbroken or unopened containers, labeled in accordance with applicable state regulations and bearing the warranty of the producer for the grade furnished.

Fertilizer shall be distributed uniformly over the seedbed at the rate of 500 pounds per acre. As indicated in the items of work and construction detail, fertilizer shall be applied according to one of the following methods. Method 1 is the preferred approach (see Section C - Mulching):

Method 1 - Fertilizer may be applied in any way that will result in uniform distribution. Incorporation into the soil is desirable.

Method 2 - The fertilizer, seed, and wood fiber mulch shall be mixed and applied hydraulically in the form of a slurry.

C. MULCHING

1. Introduction

Application of mulch increases plant establishment and protects a disturbed site from erosive forces. Mulch helps hold fertilizer, seed and topsoil in place in the presence of wind, rain and runoff and maintains moisture near the soil surface. Commonly used mulches include straw, wood fiber, wood chips or bark, fabric or mats, soil and gravel.

The choice of mulch is determined by site characteristics, product availability, cost and effectiveness. Robert Slayback of the SCS Plant Materials Center and other vegetative experts, claim that straw mulch offers the best results for both site protection and encouragement of plant growth. "Hydraulic mulching offers a weed-free mulch of low fire hazard, with possible labor-saving in application methods, but it is not always as effective as straw."(3)

The effectiveness of straw mulch is usually enhanced by the addition of a binding agent. The binding may be done mechanically (such as by punching or crimping straw into the ground) or by applying a chemical tackifier, additional fiber or a netting. These techniques are discussed in detail in the following section.

2. Recommmended Mulching Procedure

Consultation with vegetative experts in California review of the available data, field inspection of the erosion control demonstration project at Lake Tahoe and discussions with erosion control specialists in California and Maryland have produced the recommendation that straw is the best mulch material.

Tables 1, 2, and 3 present test results on the effectiveness of straw and other mulching materials. Table 2 shows that straw bound together with a tackifier (either with a chemical or with wood fiber) is highly resistent to wind. No more than 50% of the straw could be removed in winds greater than 84 mph (with tackifiers applied at the levels shown).

Table 3 compares the effectiveness of wood fiber and straw on the emergence of Blando brome seedlings. The table shows that seedling density using straw plus tackifier was 4-6 times greater than the density obtained with an equivalent amount of wood fiber (2000 lbs/acre). Increasing the wood fiber rate to 3000 lbs/acre did not significantly change the effectiveness ratio in tests performed at Davis, California.

Table 1 compares costs and effectiveness of a wide variety of seeding and mulching practices. The top part of the table covers seeding practices without mulching and seeding with hydraulic mulching at different application rates. While hydraulic mulching does offer adequate erosion protection once plants are established, its pre-germination effectiveness is minimal. The bottom part of the table contains mulching practices which are highly effective at controlling erosion in both the pre- and post-germination conditions. The most cost-effective technique on the Table is No. 3 (straw blown on at 3,000 lbs/acre and tacked down). This technique offers moderately high pre-germination protection and very high protection after plant establishment, at a cost of $880/acre.

The cost of applying straw mulch plus a tackifier is slightly higher than the cost of hydraulic mulching with wood fiber at 1500 lb/acre. However, since hydraulic mulching provides far less erosion protection prior to germination, it will probably require reapplication more often than straw. In addition, sediment removal may be required if the hydraulic mulch fails to hold. Thus, the ultimate cost of hydraulic mulching will probably be higher than straw mulching.

TABLE 2. EFFECT OF TACKIFIER PRODUCTS ON WIND STABILITY OF BARLEY STRAW BROADCAST AT 2,000 LB/ACRE.

Product	Rate/acre Chemical	Fiber-lb	Water-gal	Wind speed (mph) at which 50% of straw was blown away
None				9
SS-1 asphalt	200 gal			40
SS-1 asphalt	400 gal			80
SS-1 asphalt	600 gal			84++
Fiber only		484		47
Fiber only		736		84
Fiber only		986		84++
Terratack I	45 lb	150	750	68
Terratack II	90 lb	300	1500	84++
Ecology Control M-Binder	100 lb	150	700	84+
Styrene butadiene copolymer emulsion	60 gal	75	400	84
Polyvinyl acetate	100 gal	250	1000	54
Copolymer of methacrylates and acrylates	100 gal	250	1000	76

TABLE 3. EFFECT OF HYDROMULCH FIBER RATE OR STRAW ON EMERGENCE OF BLANDO BROME (BROMUS MOLLIS) ON DIFFERENT SOILS AND SLOPE GRADIENTS.

Treatment	Approx. lb/acre	No. seedlings/ft^2 Decomposed granite 2:1	1.5:1	1:1	1:1	Clay loam 1:1	Fine sand 1:1
None		7	1	0	0	0	0
Wood fiber	1,000	6	13	10	0	86	0
Wood fiber	2,000	26	29	27	14	262	3
Wood fiber	3,000	35	35	20	58	300	16
Straw + tackifier	2,000	119	131	155			
LSD 0.05		11	8	8	11	68	10

From: Kay, B.L., "Agronomy Progress Report No. 87", May 1978.

Other highly effective methods include jute netting, excelsior blankets and plastic sheeting. However, these products are very costly and are often unsightly. For these reasons, they are not recommended except under special or severe conditions.

Special Considerations for Straw Mulch

While straw mulch is a highly effective and inexpensive erosion control measure, it does have a few drawbacks. These are summarized below:

- weed growth is common (less common with rice straw, however, rice straw is difficult to obtain and to spread);
- fire hazard is greater than with hydraulic mulch;
- difficult to apply uphill and in wind; clean-up cost may be high if applied when windy;
- difficult to apply more than 50 feet from nearest access point (blowers have shorter range than hydraulic jets);**
- economical to apply only in large quantities (at least one truckload - 18 tons).

Holding Straw in Place

Straw usually needs to be held in place until plant growth begins. This tacking is required to protect against wind rather than water. Wet straw tends to "mat down" and is not easily moved. Common methods of holding straw in place include:

- crimping, disking or rolling into the soil
- covering with netting
- spraying with a chemical or fiber binder

"Crimping is accomplished with commercial machines which utilize blunt notched disks which are forced into the soil by a weighted tractor-drawn carriage. They will not penetrate hard soils and cannot be pulled on steep slopes.

** Commercial straw blowers advertise a capability of up to 15 tons/hour and distances up to 85 feet.

"Rolling or "punching" is done with a specially designed roller. A sheepsfoot roller, commonly used in soil compaction, is <u>not</u> satisfactory for incorporating straw. Specifications of the California Department of Transportation contain the following provisions (State of California 1975): 'Roller shall be equipped with straight studs, made of approximately 7/8 inch steel plate, placed approximately 8 inches apart, and staggered. The studs shall not be less than 6 inches long nor more than 6 inches wide and shall be rounded to prevent withdrawing the straw from the soil. The roller shall be of such weight as to incorporate the straw sufficiently into the soil so that the straw will not support combustion, and qill have a uniform surface.'

"The roller may be tractor-drawn on flat areas or gentle slopes, whereas on steeper slopes with top-of-slope access the roller may be lowered by gravity and raised by a winch in yo-yo fashion, commonly from a flat-bed truck. Requirements are soil soft enough for the roller teeth to penetrate, and access to the top of the slope. This is a common treatment on highway fill slopes in California. It can be used on much steeper slopes than a crimper. Punched straw may not be as effective as contour crimped straw, because of the staggered arrangement of tucked straw instead of the "whisker dams" made by crimping.

"A variety of nets have been used to hold straw in place: twisted-woven kraft paper, plastic fabric, poultry netting, concrete reinforcing wire, and even jute. Price and the length of service required should determine the product used. These should be anchored at enough points to prevent the net from whipping in the wind, which rearranges the straw.

"Perhaps the most common method of holding straw, particularly in the eastern U.S., is use of a tackifier." Chemical tacking is less expensive than mechanical tacking. "This method may be used on relatively steep slopes which have limited access and soil too hard for crimping or punching. Asphalt emulsion, the tackifier used most commonly, is applied at 200-500 gal/acre--either over the top of the straw or applied simultaneously with the straw blowing operation. Recent tests have shown that 600 gal is superior to 400 gal, and that 200 gal/acre is not satisfactory. Wood fiber, or new products used in combination with wood fiber, have been demonstrated to be equally effective, similar in cost, and environmentally more acceptable (Table 2). Terratack I is a gum derived from guar, Terratack II is semi-refined seaweed extract, and Ecology Controls M Binder is a gum from plantain, (<u>Plantago insularis</u>). The remaining products are emulsions used in <u>making adhesives</u>, paints, and other products. Though wood fiber alone is effective as a short-term tackifier, glue must be added to give protection beyond a few weeks. Increasing the rate/acre of any of the materials will increase their effectiveness." (3)

Mulching Specifications (1)

MULCH - Mulch shall be one of the following materials as approved by the government representative:

STRAW - Straw shall be new straw derived from rice, wheat, oats, or barley and be free of mold and noxious weed seed. Straw shall be furnished in air dry bales. The Contractor shall furnish evidence that clearance has been obtained from the County Agricultural Commissioner, as required by law, before straw obtained from outside the county in which it is to be used is delivered to the site of the work.

WOOD FIBER MULCH - Wood fiber mulch is a wood cellulose fiber that contains no germination or growth inhibiting factors. It is colored with a non-toxic water soluble green dye to provide a proper gauge for metering of material over ground surfaces. It has the property to be evenly dispersed and suspended when agitated in water.

MULCHING - A mulch covering shall be distributed uniformly over the surface of the seeded area. Mulching shall follow immediately after seeding. Unless otherwise directed by an authorized official, Method 1 (below) shall be used on slopes of 2:1 or less where slopes are within 50 feet of access and where wind is not a problem. Method 2 shall be used in all other cases and when straw is not available. Method 1 is the preferred method.

METHOD 1 - A straw mulch shall be applied at a rate of 2,000-3,000 lbs/acre. The mulch shall be applied by hand, blower or other suitable equipment. If straw is applied with a blower, it shall not be chopped in lengths less than six (6) inches.

The mulch will be anchored in place to prevent removal of straw by wind. The anchoring process as approved by an authorized official may include using hand tools, mulching rollers, crimpers, netting or liquid tackifiers.

METHOD 2 - A wood fiber mulch at a rate of at least 1500 pounds per acre shall be applied hydraulically in a water slurry. The wood fiber mulch, seed and fertilizer can be mixed and applied hydraulically in the form of a slurry.

D. MAINTENANCE

The critical period for vegetative stabilization is the first year. If the ground cover is not complete, rills or gullies may develop, which often grow progressively worse. Unfortunately, there are no precise performance standards for erosion control effectiveness, such as "a minimum 80% cover shall be maintained." On some sites, an 80% cover may provide adequate protection, while on other sites, it may be quite inadequate. Though establishment of a 100% plant cover on a site is the

objective, achieving this high level is extremely difficult. Nevertheless, the following general maintenance guidelines can be followed:

Inspection

Sites should be inspected within 30 days after planting or within 30 days after the first rain. Follow-up inspections 60-90 days thereafter and once again in the spring are advised. If the site is well stabilized in spring, no further inspections should be necessary.

Reseeding and Repair

Slopes should be repaired and/or reseeded if the following conditions are observed:

- o erosion on bare areas of slope
- o sheet or rill erosion has occurred
- o sediment buildup at toe of slope

Rills or gullies should be filled or smoothed over before reseeding. If rill occurrence is extensive, the entire slope may require regrading before reseeding. In such cases, the inspector should determine whether a diversion measure above the slope is required to divert runoff away from the slope. If a diversion measure is present, it should be inspected to see that it is working properly.

E. SUMMARY AND CONCLUSION

Vegetative slope stabilization, if done properly, is a highly effective and low cost means for controlling erosion and sedimentation from construction activities. The costs for seeding and mulching are low compared to the costs of:

- o other construction activities (such as earth-moving)
- o structural control measures (such as permanent sediment basins)
- o dredging sediment from streams, lakes and reservoirs.

Grass provides the best plant cover for erosion protection. Sites should be seeded, fertilized and mulched immediately after construction is completed and before September 15th. Anchored straw mulch provides the most effective protection for plant establishment. In many cases, it is also the most cost-effective method. Hydraulic mulching with wood fiber is desirable on steep uphill slopes and where access within 50 feet is difficult.

F. REFERENCES

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WQ/Tech Memo #44
Steven J. Goldman/Emy Chan

WATER QUALITY MANAGEMENT PLAN

OUTLINE FOR WATERSHED PLAN FINAL REPORTS

Technical Memorandum No. 44
February 1980

BACKGROUND

The 1979-80 Work Program contains five major watershed case studies:

Task 22 - Develop erosion control plan for Cull Canyon
Task 23 - Develop water quality protection plan for Nicasio Valley
Task 24 - Develop erosion control plan for Pescadero Creek Watershed
Task 25 - Develop pollution control plan for San Mateo Lagoon
Task 27 - Develop erosion control plan for Calabazas Creek Watershed

These five tasks constitute about 60 percent of the total county budgets for this year's "208" program. These case studies are intended to yield implementable plans for the affected watersheds. The plans developed for these areas can also serve as a model for plans in other watersheds.

The watershed plans will form a part of the updated County Surface Run-off Plans and the updated Environmental Management Plan for the San Francisco Bay Area. These plans should, therefore, be prepared in a reasonably consistent format. The purpose of this memorandum is to provide guidelines for the preparation of these documents.

RECOMMENDED PLAN OUTLINE

1. Introduction

   - Brief problem statement
   - Objectives of plan

2. Plan Summary

   - Plan summary table (see Table 1)

- Brief narrative describing plan (1-2 pages)

    - What is the plan
    - What problems are being dealt with
    - What will it cost to implement
    - Who will implement it
    - How will it be paid for
    - When will it be implemented
    - What implementation commitments have been obtained

3. Description of Watershed Conditions

- Watershed characteristics (environmental, land use, economic, etc.)
- Water quality problems and their sources
- Review of existing data
- Description and evaluation of original data collected (if any)
- Existing activities/operations in water quality problem area

4. Technical Approach

- Detailed description of methodology (e.g., methods for estimating erosion potential, soil loss, development suitability, etc.)
- Data analysis (documentation of technical work can be presented in an appendix, if appropriate)
- Assessment of critical factors or key target areas for watershed protection plan

5. Plan Development

- Formulation of alternative control measures or plan components
- Evaluation of alternative measures or plan components (e.g., effectiveness, cost, ease of implementation, etc.)

6. Watershed Protection Plan

This section should describe in detail the items in Table 1.

- Problem: The specific pollution problem(s) that the policies were formulated to solve.
- Policy: The overall objective of one or a group of related control measures identified as actions.

- Action: The specific control measures to be taken to implement a policy.

- Description: Supplementary information about each action including a brief explanation of what the action consists of and where in the watershed it is to be applied.

- Implementing Agency: The agency or agencies responsible for initiating and coordinating the action. In some cases there may be a need to have one lead agency coordinating the efforts of several implementing agencies (see example in Table 1).

- Scheduling of Actions: The timetable for implementation. It should include the data on which an action is initiated, the date by which the action should be operational and the duration of the action (see Figure 1).

- Legal Authority and Enforcement: The constitutional provisions, statutes, or ordinances which enable the implementation and enforcement of the action. If no such enabling legislation exists, counties should specify what is required. Penalities for non-compliance with the control measure should be specified.

- Cost to Implement: Estimated cost to develop and administer the control program. Cost should be broken down into categories such as: plan review (including technical analysis and communication with applicant), site inspection, staff training to administer control programs, public information

- Financing mechanisms: The sources or potential sources of funding the action.

- Remarks: Optional comments about any item in the table, such as incentives for encouraging participation in the action.

7. Implementation Commitments

- List of implementing agencies

- Summary of contacts with implementing agencies

  - meeting dates
  - persons contacted
  - reactions to plan

- Public hearings and/or public discussions held
  (City council or board of supervisor consideration of plan)

  - include dates of hearings and summary of discussion

- Calendar of events for review and adoption of plan (see Figure 1)

Appendix A: Support Data (Documentation of technical work such as compiled data, calculations, inventories, etc.

Appendix B: Assessment of Control Program

Impact assessment summaries such as presented in Tables 2 and 3 should be prepared. These tables are companions to the plan summary table and display key information to decision-makers.

The assessment summary table should be divided into the four major headings that appear on the summary table--Environmental Impacts, Institutional/Financial Impacts, Economic Impacts and Social Impacts. This organization reflects the categories of the Assessment Checklist from the <u>Surface Runoff Assessment Procedures Manual</u>.

It is suggested that where impacts are already discussed in detail in the Watershed Protection Plan or its development, reference can be made to those sections. If appropriate, an index to the assessment discussions within the control program can be presented here.

Table 1. Sample Plan Summary*

for a Watershed Protection Plan

Problem	Excessive sedimentation in Calabazas Creek
Recommended Control Measure	
Policy	To reduce sediment from urbanization in the Calabazas Creek Watershed
Action	Adopt ordinance regulating development in watershed subareas based on sediment yield potential
Description	Subareas mapped by erosion potential (E) Sediment yield potential (Y) calculated for each subarea. Y=RKLSCP (R,K.L,S,C and P factors for each subarea are shown in Appendix) Control measures are based on Y values: Low ($<$x tons/yr) - Group 1 control measures Medium ($<$y tons/yr) - Group 2 control measures High ($>$z tons/yr) - Group 3 control measures
Implementing Agency	Santa Clara County (lead agency) and City of Saratoga assisted by Evergreen RCD under a MOU
Schedule of Actions	Ordinance preparation: July - Sept. 1980 City Council and Board of Supervisors review: Oct. 1980 Ordinance adoption: Nov. 1980
Legal Authority and Enforcement	Enforced by public works and planning departments using permit approval authority
Financing Mechanisms	Application fee proportional to project size $10/100 sq. ft. of building area
Cost to Implement	City of Saratoga application fees $10,000/yr Planning Dept.: 4 person-months/yr Public Works: 3 person-months/yr Santa Clara County application fees $6,000/yr Planning Dept.: 2½ person-months/yr Public Works: 1 person-months/yr
Remarks	If developer can demonstrate to the satisfaction of planning/public works departments that site conditions have lower E value than subarea map, exemptions may be permitted

* All information in table is for illustration purposes only. It is not based on actual data.

FIGURE 1

SEQUENCE OF ACTIVITIES FOR INITIATING SAMPLE CONTROL MEASURE

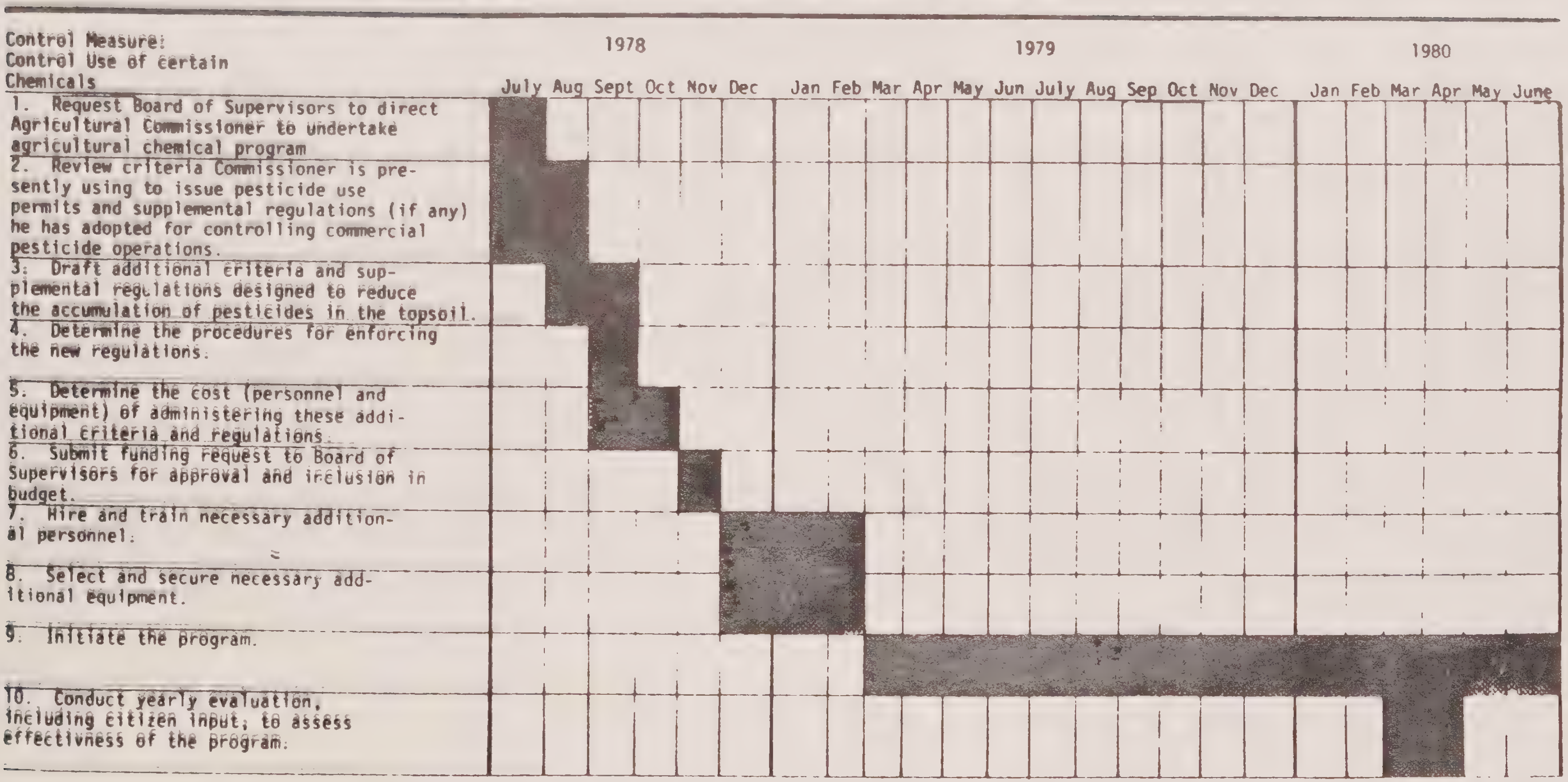

Table 2. IMPACT ASSESSMENT SUMMARY

CONTROL MEASURE/ RECOMMENDATION	ENVIRONMENTAL IMPACTS	INSTITUTIONAL/FINANICAL IMPACTS	ECONOMIC IMPACTS	SOCIAL IMPACTS
Policy - Reduce Litter in Streams Action 2.2 - Monitor streams for illegal dumping, investigate source and take corrective action through to prosecution. Anti stream litter public information program.	AIR QUALITY - . minor indirect benefits of reduced odors associated with litter & debris decomposition WATER QUALITY - . maintenance of natural flow regimes major benefits during summer months when low flows are exacerbated by channel blockage . BOD levels associated with litter decomposition should be lower . prevent reductions in productivity of aquatic community - fish, consumer organisms, producers - that result from changes in the natural flow regime . prevent reductions in contact (e.g. swimming) and non-contact (e.g. sport fishing) water recreation potential PHYSICAL RESOURCES - . major benefits to the aquatic community . indirect benefits of enhanced land and water related recreation potential and use ENERGY - . no impact - clean-up handled by small scale operation AMENITIES - . direct benefits of visual impacts of debris removal from streams and stream banks - preservation of the natural state of the environment & scenic resources	FINANCIAL - Direct Cost - Public . Administrative/Regulatory Cost $37,000 annual cost(See back-up cost tables) Fiscal Effects on Local Government . minor impacts on the property tax rate- increased tax rates INSTITUTIONAL - . minor impacts on intergovernmental cooperation - other agencies may patrol streams for other purposes and contribute valuable assistance . minor impacts on legal capabilites existing ordinances, statutory responsibilities may need modified	PRODUCTION OF GOODS AND SERVICES . minor impacts of increased employment in scavenger and related businesses INCOME AND INVESTMENT - . no impacts CONSUMER EXPENDITURES - . no impacts	HOUSING SUPPLY - . no impacts PHYSICAL MOBILITY - . no impacts HEALTH AND SAFETY- . indirect, major benefits of reduced flood peaks and flood risks associated with channel obstructions . direct benefits of eliminating environments for growth of noxious species of plants and/or animals (e.g. algal blooms, rat and mosquito breeding) EQUITY - . while benefits are distributed approximately equally, costs are borne disproportionately by lower income people because the property tax is regressive URBAN PATTERNS - . no impacts

Table 3. IMPACT ASSESSMENT SUMMARY

CONTROL MEASURE/ RECOMMENDATION

Policy - Reduce erosion, sediments in water bodies, siltation

Action 3.4 - Require Sediment Control Plans to Accompany Plot Plans, Building & Grading Permit Applications

(Actual impacts would be site specific & require detailed assessment. Impacts noted are general impacts expected.)

ENVIRONMENTAL IMPACTS

AIR QUALITY -

. indirect, localized, beneficial impacts of reduced amounts of dust

WATER QUALITY -

. reduced amounts of sediment entering water bodies from construction sites by 100 tons/sq.mi/year

. reduce suspended solids available for chemical, pesticide and heavy metal binding

. reduced changes (increases) in turbidity, light penetration

. reduced increases in siltation of water bodies due to construction site runoff;maintain natural flow regimes especially during summer

. prevent reductions in productivity of aquatic community - fish, consumer organisms, producers - associated with adverse impacts on photosynthesis, siltation etc.

. prevent reductions in contact (e.g. swimming) and non-contact (e.g. sport fishing) water recreation potential

PHYSICAL RESOURCES -

. indirect benefits to the aquatic community, wildlife habitats

. indirect recreation potential and use benefits (land and water oriented)

ENERGY -

. indirect, minor impacts associated with machinery and products used

AMENITIES --

. indirect benefits of the visual impacts of reduced turbidity

. visual benefits of preserving scenic resources, natural state of the environment

INSTITUTIONAL/FINANCIAL IMPACTS

FINANCIAL -

Direct Cost - Public

. no additional staff required. any additional costs would be minor and offset by permit fees.

Fiscal Effects on Local Government

. permit fees will increase gross receipts and mitigate administrative/regulatory costs

. performance bonds will mitigate any costs for clean-up, litigation etc.

INSTITUTIONAL -

. minor impacts on legal capabilities - existing ordinances & regulations may need modification; administrative rulemaking may be required

. additional review & inspection tasks mitigated by implementation through existing administrative process.

. implementing agency staff may resist additional review & inspection responsibilities or lack appropriate expertise

. some jurisdictions may resist imposing further requirements on developers

ECONOMIC IMPACTS

Direct Cost - Private

O&M Costs (Examples of Cost of Several Best Management Practices)

Straw Bale Barrier
$2.14/ lineal foot
Siltation Berm
$7.33/lineal foot
Diversion Dike
$3.64/lineal foot
Runoff Interception Trench
$6.21/lineal foot
Hydromulching
$989/acre

The cost/acre for an Industrial or Commerical project might be $ 250-450

The cost/acre for a Subdivision $ 500-700(average)

PRODUCTION OF GOODS AND SERVICES -

. indirect, minor benefits of increased employment in landscaping, engineering sectors

INCOME AND INVESTMENT -

. indirect, minor impacts on profits for above advantaged firms

. profits of firms bearing the costs of controls should not be affected assuming costs can and will be passed on to the consumer(industry dependent response)

CONSUMER EXPENDITURES -

. increased price of goods may occur (e.g. housing and products produced by industrial or commercial firms)

SOCIAL IMPACTS

HOUSING SUPPLY -

. indirect impact of reduced supply of housing may result

. added site preparation and construction control costs would increase the unit costs of new housing (e.g. the average cost of a house may increase by $200 - 600 - an example design and installation cost of a BMP)

. may reduce the likelihood of structural problems associated with slope instability,erosion

HEALTH AND SAFETY -

. indirect, major benefits of reduced flood peaks and flood risks associated with siltation

. direct, major benefits of reduced erosion- 80% reduction or 100 tons per sq. mi. per year

. reduced losses of productive topsoil, organic matter, nitrogen, phosphorus

. reduced adverse impacts on flora

EQUITY -

. increased housing costs may put housing further from the reach of low and moderate income people

URBAN PATTERNS -

. no impacts

WQ Tech Memo No. 45
Terry A. Bursztynsky

WATER QUALITY MANAGEMENT PLAN

EVALUATION OF USING PARKING RESTRICTIONS TO INCREASE STREET SWEEPING EFFECTIVENESS

Technical Memorandum No. 45

February 13, 1980

INTRODUCTION

Street sweeper effectiveness is seriously hampered by the presence of parked cars on the street. When no cars block access to the curb, mechanical sweepers can remove fifty percent of the street solids. Recent advances in street maintenance procedures which may enable curbside cleaning in the presence of parked cars include manually guided, truck-mounted, vacuum "wands" and special curb flushing systems. Changes in street gutter design are necessary, however, to allow flushing water to flow past curbed tires with the latter alternative. Currently curbside cleaning is most commonly optimized by enforcing parking restriction ordinances. These regulations can be very effective in maximizing street solids removal but the associated costs are also significant. Direct costs consist of purchase, installation and maintenance of "no parking" signs and vehicle and personnel expenses for enforcement of the regulations. These expenses are offset somewhat by revenues from citations of violators. Less readily quantifiable are the personal inconvenience and disruption of commercial activity which results from parking restrictions. These problems can be ameliorated somewhat through public awareness campaigns and practical measures such as minimizing the time when the restrictions are in effect and scheduling the restrictions for either side of the street on alternate days.

Lack of public acceptance where the parking shortage is especially severe may force cities to opt for other management practices over parking restrictions. Most cities have manual sweeping crews to service downtown areas or small business areas during daytime hours. Where parking is scarce, however, some residential neighborhoods are swept manually also. (Sartor and Boyd, 1972). Another approach that has been used to give mechanical sweepers curb access is scheduling sweeping during rush hours when tow-away zones are enforced; however, this can create serious traffic problems. (Abt Associates, Inc., 1977).

The purpose of this technical memorandum is to weigh the costs of instituting and enforcing parking restrictions against the benefits from increased solids removal that would result.

SUMMARY AND CONCLUSIONS

1. Parked cars seriously affect the cost per unit solids removed by mechanical street sweepers.

2. Parking restrictions are cost effective if the following curb occupancy conditions apply:

sweeping frequency	sweeping costs $7/curb mile	$12/curb mile
daily	100%	100%
weekly	>30% but <90%	>10% but <90%
monthly	never	70%

3. The formula defining the unit removal cost ratio for instituting parking restrictions is given as a function of the normal curb occupancy, sweeping frequency and sweeping costs.

PROBLEM ANALYSIS

The comparison of parking restriction costs with the accompanying street solids removal increases requires that a number of assumptions be made. These simplifying assumptions are necessary because the same costs and constraints are not common to all cities. The assumptions used in this analysis are as follows:

1. Street Sweeping Costs: The costs of street sweeping one curb mile range from $7 to $12 (Yucel, 1979). Although parked cars affect street sweeper speed, this relationship was not explicitly included in the analysis. The dollar value range given is simply designed to bracket reported costs of street sweeping in Bay Area communities. Parking restriction costs are not included in this range.

2. Street Sweeper Effectiveness: This analysis is limited to the use of mechanical sweepers on asphalt streets. Locally this combination is encountered most frequently and is best documented in the professional literature. Generally more than ninety percent of street solids occur in the parking lane. Solids deposited in traffic lanes are blown by wind and traffic-induced air currents to the side of the street where the curb acts as a physical barrier, causing accumulation to take place. In the special case where the parking land is fully occupied most of the time, the parked cars themselves act as a barrier. Thus, the bulk of the accumulation happens inward

of the parking lane rather than at the curb. This phenomenon is illustrated by Figure 1. With extensive long term parking most of the solids accumulation is ten to twelve feet from the curb. Figure 2 shows the percent total solids removal as a function of the percent curb length occupied by parked cars. Table 1 lists the values used in constructing the curves of Figure 2. With no parking restrictions, the maximum (fifty percent) solids removal occurs when the curb is usually unoccupied or when it is occupied most of the time. Maximum removal can be obtained with ninety percent occupancy in areas of extensive 24-hour parking. Cars that occupy the parking lane most of the time prevent the street solids from being blown to the curb. Instead they accumulate between the curb lane and the traffic lanes and are accessible to sweepers while parked cars are present.

Without parking restrictions, intermediate curb lane occupancy levels drastically lower sweeper effectiveness. As Table 1 shows, with 50% to 60% of the curb length occupied, 24% less of the total street solids are removed in the absence of parking restrictions. This amount of solids removal foregone represents about half of the maximum fraction of street solids that is removable by mechanical street sweepers. The large difference between sweeper effectiveness with and without parking restrictions at intermediate curb occupancy levels arises because the parking density is low enough for the street solids to be blown to the curb, yet high enough to prevent the sweeper from reaching much of the curb without parking restrictions.

In the case of completely effective parking restrictions, good sweeper performance is obtained in areas where up to about seventy percent of the parking lane is normally occupied (Figure 2). Beyond this level, sweeper effectiveness falls sharply because less of the street solids have been blown to the curb. Solids that accumulate ten to twelve feet from the curb are missed by the sweeper's curb-side, eight-foot, swath. The street solids distribution and sweeper effectiveness relationships used here were developed in a recent San Jose street cleaning practices study (Pitt, 1979).

3. Parking Restriction Costs: The estimated costs of effective parking restrictions are $182 per curb mile per year for posting and maintaining signs and $0.23 per curb mile cleaned for enforcement of the ordinances. These costs are based on a recent Los Angeles Area study (Gilbert, J.B. and Associates, 1978). It was assumed that 32 signs would be required per curb mile, that the cost and installation was $40 per sign, and that the cost would be amortized at 7 percent over the estimated ten-year useful life of each sign. Extra enforcement costs were estimated based on costs for an enforcement officer, a vehicle, operation and maintenance of the vehicle, and administration of the program, totaling $17,500 annually. This officer would cover eighty curb miles swept per day at a frequency one-half that of the street sweeper.

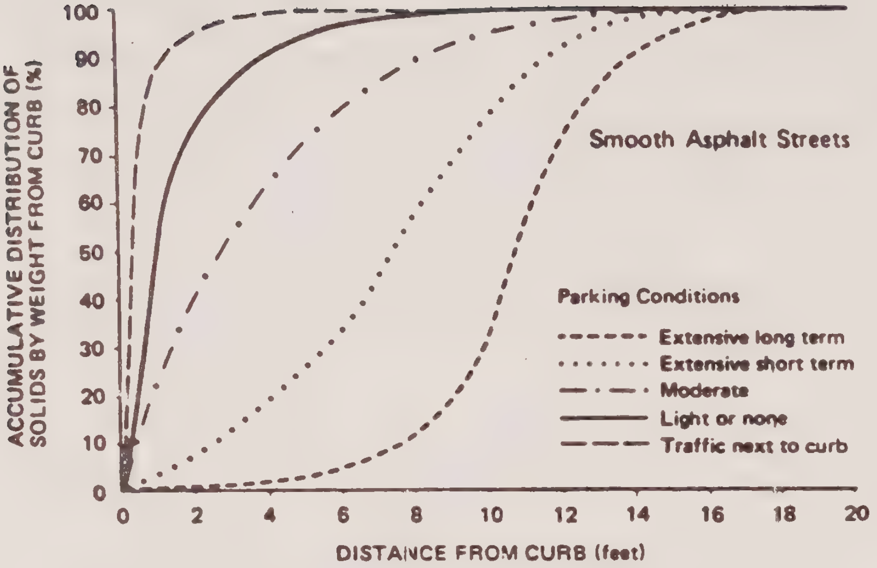

Figure 1. Effect of parking on street solids loading distribution.
Source: Pitt, 1979.

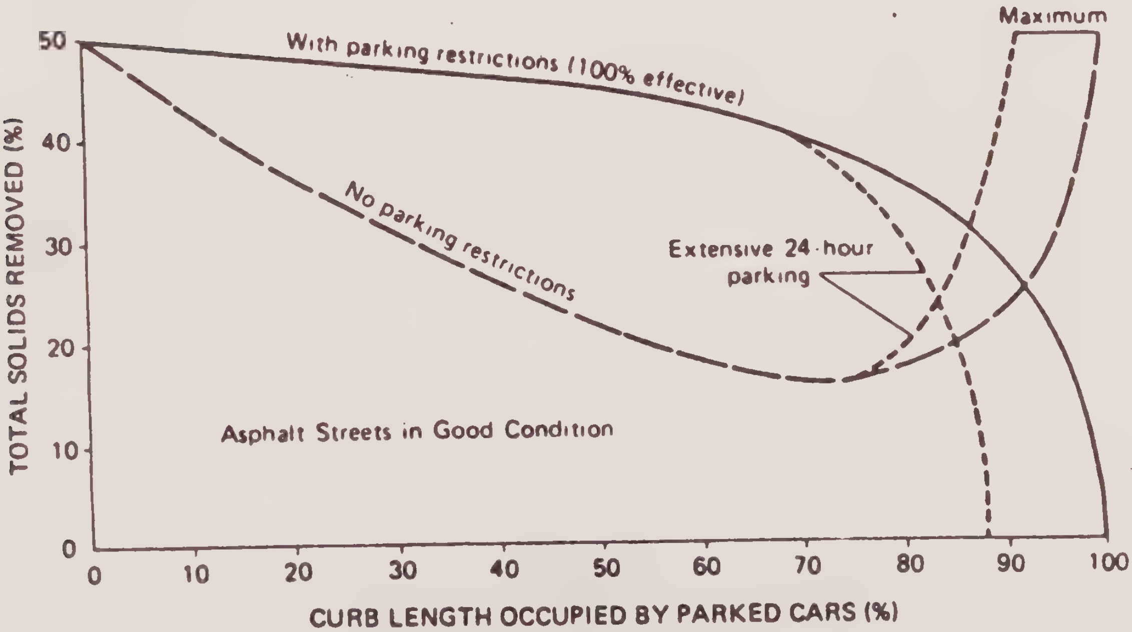

Figure 2. Effect of parking restrictions during street cleaning.
Source: Pitt, 1979.

TABLE 1. PARKED CAR EFFECT ON STREET CLEANING EFFECTIVENESS

Percentage of Curb Length Occupied	Parking Category	Percentage of Curb Length Cleaned (0 to 8 ft. Cleaning Path)	Percentage of Distance Cleaned Around Cars (8 to 5 ft. Cleaning Path)	% of All Solids Removed with Parking Controls & Operated Next to Curb with a 0 to 8 ft. Cleaning Path	% of Total Solids Removed if the Cleaning Path is 8 ft. to 16 ft. From Curb	% Total Street Solids Removed with No Parking Controls and with Cleaner Moving Around Cars as Necessary
0	none	100	0	50	0	50
10	light	86	14	49	1	42
20	light	75	25	48	2	36
30	light	63	37	47	3	31
40	moderate	53	47	46	4	26
50	moderate	41	59	45	5	21
60	moderate	30	70	43	8	19
70	moderate	19	81	39	11	16
80	extensive	10	90	35	16	18
90	extensive	0	100	28	23	23
100	extensive	0	100	0	50	50
80% for 24 hrs.	extensive	0	90	30	21	19
90% for 24 hrs.	extensive	0	100	0	43	43
100% for 24 hrs.	extensive	0	100	0	50	50

Source: Pitt 1979

By setting the benefit of removing street solids equal to current sweeping costs, a unit removal cost comparison may be made. Of course, intangibles such as personal inconvenience and unquantified receiving water benefits are not included in the comparison. If the incremental unit solids removal cost associated with parking restrictions is less than the unit cost without restrictions, the parking ordinances are deemed warranted. Otherwise they are not.

The ratio of the incremental unit cost to the non-restricted parking unit cost is given by:

$$\text{Ratio} = \frac{\dfrac{(\text{incremental percent total solids removed with restrictions})}{(\text{cost of parking restrictions})}}{\dfrac{(\text{percent total solids removed without restrictions})}{(\text{sweeping program costs without restrictions})}}$$

Mathematically, this relationship is expressed by:

$$\text{Ratio} = \frac{\dfrac{(182/f) + .23}{RR - CR}}{\dfrac{CC}{CR}}$$

where f is the annual sweeping frequency and takes on the values 12, 52 and 260 for monthly, weekly or daily sweeping respectively, RR is the restricted parking total solids removal in percent (column 5 of Table 1), CR is the current total solids removal in precent (column 7 of Table 1), and CC is the current sweeping costs in dollars per curb mile ($7 or $12).

Table 2 lists the unit removal cost ratio for enforced parking restrictions as a function of percentage curb length usually occupied, sweeping frequency and current sweeping costs. When the ratio is less than one, the additional solids removal due to parking restrictions is effected at a lower unit cost than is obtained without restrictions. A ratio greater than unity indicates that additional solids removal by restricting parking is not warranted economically.

Table 2 shows that in areas that are swept daily, parking restrictions are favored, except with nearly complete curb length occupancy, regardless of sweeping cost in the range examined. Restrictions ought to be employed in areas that are swept weekly if the curb occupancy is greater than thirty percent but less than ninety percent when sweeping costs are $7 per curb mile; and greater than ten percent but less than ninety percent when sweeping costs are $12 per curb mile.

TABLE 2. Unit Removal Cost Ratio for Enforced Parking Restrictions

percentage of curb length occupied	current sweeping costs = $7/curb mile			current sweeping costs = $12/curb mile		
	sweeping frequency			sweeping frequency		
	daily	weekly	monthly	daily	weekly	monthly
10	0.80	3.20	13.20	0.47	1.87	7.70
20	0.40	1.60	6.60	0.23	0.93	3.85
30	0.26	1.03	4.26	0.15	0.60	2.49
40	0.17	0.69	2.86	0.10	0.40	1.67
50	0.12	0.47	1.92	0.07	0.27	1.12
60	0.11	0.42	1.74	0.06	0.25	1.02
70	0.09	0.37	1.53	0.05	0.22	0.89
80	0.14	0.56	2.33	0.08	0.33	1.36
90	0.61	2.45	10.12	0.36	1.43	5.90
100	*	*	*	*	*	*
80% for 24 hrs.	0.23	0.92	3.80	0.13	0.54	2.22
90% for 24 hrs.	*	*	*	*	*	*
100% for 24 hrs.	*	*	*	*	*	*

NOTE: The table entries are unit removal cost ratios using the values on Table 1 with the equation and the cost assumptions given herein.

* Negative ratio due to lowered solids removal with parking restrictions.

The only situation when parking restrictions are called for on streets swept monthly is when the usual curb parking density is seventy percent and sweeping costs are $12 per mile. Implementing parking restrictions is increasingly favored as sweeping costs increase and with increased frequency of sweeping.

An alternative way of viewing the benefits of enforced parking restrictions is from an annual sweeping program expenditure perspective. Consider a hypothetical city that spends one million dollars per year on street sweeping without parking restrictions. At $7 per curb mile swept, about 143,000 curb miles are swept annually. If the usual curb occupancy level is 20 percent, Table 1 shows that 36 percent of the total street solids are being removed whereas 48 percent could be removed with parking controls. Thus 25 percent of the potentially removable street solids are not swept up. In other words, $250,000 of the street sweeping program expenditure is lost. Assuming the average sweeping frequency for the hypothetical city is once per week, then the cost of parking restrictions would be $\{([\$182/\text{curb mile/yr}] \div 52 \text{ sweeps/yr}) + \$0.23/\text{curb mile swept}\} \times 14300$ curb miles swept/yr. This amount is about $533,000 per year. By spending this amount, the $250,000 previously wasted is recovered and 48 percent of the total street solids is removed rather than only 36 percent. If this analysis is done assuming a sweeping cost of $12 per curb mile, then the additional expenditures for parking restrictions would be only about $311,000. This figure is less because the hypothetical city swept for one million dollars at the more expensive rate would have fewer curb miles swept.

Parking restriction costs may be offset somewhat by revenues from parking violation citations. For example, in weekly swept areas, the annual parking restriction program costs are about $182 plus $0.23 x 52, or $194 per curb mile. If the citation bail is $5, only 39 tickets per curb mile per year would pay for the entire program costs. This is less than one citation per curb mile per week. Although bail is not posted on all citations issued, enough revenues can be collected to offset most, if not all, of the parking restriction program costs. The amount of parking citation offset revenue varies widely depending on how high bail is set. If the parking restrictions are less than 100 percent effective and 2 percent of the curb is occupied, about 6 or 7 cars per curb mile would be present for ticketing. This is far more than the number necessary to offset the program costs.

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WQ/Tech Memo No. 46
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WATER QUALITY MANAGEMENT PLAN

FINANCING SURFACE RUNOFF AND EROSION CONTROL MEASURES IN URBAN AREAS*

Technical Memorandum No. 46
February 20, 1980

I. FEDERAL ASSISTANCE

If one had to select the major deficiency of 208 water quality management plans submitted to the Environmental Protection Agency over the last two years, it would clearly be the lack of attention to how much surface runoff and erosion control measures cost and how they are to be paid for. The 226 state and areawide plans, which cost some 220 million dollars to prepare, gave some attention to the former and almost ignored the latter. At an ABAG conference titled "Paying for Environmental Management" held last summer, an EPA representative said that the plans failed to consider fundamental funding problems and that they "haven't discussed their fiscal impacts in ways local legislators and taxpayers can understand." He went on to say that local cost calculations need to be presented right down to the per household cost "so the individual knows what it means to him." A staff member of a House of Representatives committee with responsibility for EPA's budget responded that even with this detailing of costs, the solutions to our erosion control and surface runoff problems are very expensive and that Congress "doesn't have the foggiest idea how we're going to fund them." The funding approach most common in Washington is to find what the "reasonable costs" are. The control measure costs in the plans must be considered "unreasonable"--or unsupportable--since EPA's present position is that Federal funding for 208 plan implementation is going to be limited or non-existent for the next few years.

What are these cost estimates? The first national attempts to estimate the financial costs of stormwater control were made by the National Commission on Water Quality about six years ago. It was evident that the costs of treatment of urban runoff would be astronomical--something on the order of 199 billion dollars in 1974 dollars. The concept of Best Management Parctices (BMPs) to reduce and prevent pollution thus quickly gained popularity. The costs for BMP implementation were determined to be much less, but still large--it was found that the implementation of nonstructural techniques would require a national capital expenditure of about six billion dollars with O&M costs

* Sources of funds to finance construction, operation and maintenance of municipal wastewater systems are discussed in: "Financing Municipal Wastewater Facilities," ABAG Water Quality Management Technical Memorandum No. 9, February 28, 1977.

of about 500 million dollars a year (Figures 1, 2). Removal rates for suspended solids were also found to be as high as three times that of treatment.

Since the Commission went out of business, both higher and lower estimates have been announced. For example, EPA's 1978 Construction Grants Needs Survey estimated the cost of controlling urban runoff from pipes--not including overland runoff--at over 60 billion dollars. Of course, there is no doubt that any national estimate contains large inaccuracies. The value of these estimates is that they all show a large difference in the costs required between treatment and BMPs as well as a threefold difference in removal rates. Thus, even assuming widely fluctuating values, Best Management Practices are largely accepted as the most practicable means to achieve stormwater runoff control. Similar national figures for erosion and sedimentation control don't exist, but the emphasis on BMPs is similar.

Even with the lower costs of BMPs, implementation programs are still expensive. The ABAG conference on funding concluded on a general note of pessimism. Observers noted that there seemed to be a conscious or unconscious unwillingness to talk about tough financing questions. Financial consultants emphasized that the technical solutions to our environmental problems are coming along, but that management and financing issues remain. As a group, they felt that state and local government staff have been unwilling or unable to closely relate technical, management and financing questions when developing environmental controls. One local government staff member responded that it is hard to sell locally elected officials on surface runoff controls when the benefits of such controls are so poorly defined and there is no Federal cost sharing program. The concluding panelists agreed that innovative, alternative approaches to funding--which do not rely on a Federal grant or local property taxes--will be necessary. No one, however, had a simple solution to a very complicated funding dilemma. Specialized Federal demonstration funds and revenue sharing funds will continue to be available, but a billion dollar grant program similar to that for municipal wastewater treatment facilities seems very unlikely.

II. STATE ASSISTANCE

The possibility for increased financial aid from the State to local governments for implementing new or expanded programs is highly unlikely. Even if Jarvis II (called Jaws II in governmental circles) is defeated, the 1980-81 fiscal year will likely be the last in which State and local government can be supported by the huge surplus that accumulated in the State treasury during the 1970s. Passage of the Jarvis initiative, which would cut personal income taxes in half, would cost the State 5 billion dollars in the 1980-81 fiscal year--roughly 25 percent of the general fund. Unless modified in the Legislature, the blow would be especially hard in the first year because the income tax cut would cover the entire 1980 calender year. This means that the 1980-81 budget would have to absorb an income tax cut covering 18 months. In the following fiscal year, the loss would be about 4 billion dollars. If Jarvis II passes, it is anticipated that local government will be hit harder than State agencies. That is because almost 80 percent of the general fund budget of 20.7 billion dollars goes for local assistance.

FIGURE 1. TREATMENT COMPARED TO BMPs
(URBANIZED AREA U.S.)

ALTERNATIVE	ANNUAL REMOVAL SUSPENDED SOLIDS (tons x 1,000)	TOTAL CAPITAL REQUIRED ($ x 1,000)	ANNUAL O+M REQUIRED ($ x 1,000)
LEVEL THREE ABATEMENT BY TREATMENT	10,300	199,000,000	1,000,000
BMP	29,476	6,136,588	512

Note: Level 3 Abatement considers the following reductions: 60% SS, 35% BOD, 15% Nitrogen, 35% Phosphorus, 99.9% Bacteria

FIGURE 2. ESTIMATES OF COST AND EFFECTIVENESS FOR BMP TECHNIQUES
APPLIED TO THE URBANIZED U.S.

TECHNIQUE	ANNUAL REMOVAL SUSPENDED SOLIDS (tons x 1,000)	TOTAL CAPITAL REQUIRED ($ x 1,000)	ANNUAL O+M REQUIRED ($ x 1,000)
STREET SWEEPING	3,844	105,326	99,191
CATCH BASIN CLEANING (UNSWEPT AREAS)	19, 900	-------*	51,450
CATCH BASIN CLEANING (SWEPT AREAS)	130	-------*	438
DETENTION TANKS	299	4,675,926	93,517
SEWER FLUSHING	53	1,211,336	268,022
DIVERSION BERMS	5,250	144,000	-----**
TOTAL COSTS AND EFFECTS	29,476	6,136,588	512,663

* assume cleaned by hand

** no data

The reason why the "bail-out" is coming to an end, even without Jarvis II, is a shart decrease in State revenues. Among major taxes, only the sales tax is holding up well. Growth in the personal income tax has been dramatically reduced by the initiation of the so-called indexing (adjustment for inflation) system. As a result, revenues from the income tax are projected at $618 billion for the year--down $1.4 billion from the level it would have reached without reductions enacted over the past few years.

If any of this comes to pass, one can only speculate on how water quality decisions will be made in California. As the municipal wastewater facility construction program is completed, it is possible that the State Water Resources Control Board and the regional water quality control boards will take a much more active regulatory role in erosion and surface runoff control. Alternatively, the State role might evolve into one of technical assistance and monitoring. In any case, some redefinition of responsibilities seems likely between the State and local governments as State and local budgetary limits tighten.

III. LOCAL GOVERNMENT FISCAL CAPABILITIES

With the passage of Propositions 13 and 4 and the upcoming vote on Proposition 9 (Jarvis II), it is impossible to make any sweeping generalizations about the capability or the willingness of local governments to expand their efforts to control erosion, sedimentation and nonpoint sources of water pollution. A quick dismissal of any new programs, although the conventional wisdom, is probably too simple a response. It is more appropriate to attempt to make some specific conclusions about the impact of these propositions on local government and then see how water quality management programs might be financed at the local level.

Impacts of Proposition 13, 4 and 9

To start, it is ironic that Proposition 13, which resulted from residential property owners' grievance over high property taxes, is expected to make residential property bear a greater portion of the total property tax burden than before. A new base year is assessed with a change in ownership, and residential property turns over on the average of once every five years while commercial or industrial turnover is on a 20-year or longer cycle. Without legislative reform, the tax burden will increasingly shift away from those sources which traditionally carried the heaviest tax burden.

Formation of new local governmental units, whether cities or special districts dependent upon property taxes, is likely to decrease considerably. This is because a new entity is entitled only to that portion of the property tax revenues from the parent jurisdiction that were used to finance services being transferred to the new entity. While the parent entity might have had nonproperty tax revenues, the new entity must obtain the approval of two-thirds of the "qualified electors" to levy nonproperty taxes, even operating under the assumption that the entity is legislatively authorized to impose certain nonproperty taxes. Given the political climate in the State, it seems that such approval would be difficult to obtain. Moreover, special districts are rarely authorized to impose nonproperty taxes.

In the case of the opposite possibility, annexations, the two parties have to negotiate the transfer of property taxes. Of course, the on-going city already has the authority to levy nonproperty taxes. Because of the possibility to achieve some economies of scale in service delivery, it is likely that there will be pressures to have special districts merge. Opposition will come from those who fear the loss of effective local control.

Paying for capital improvements that do not generate revenues is likely to be more difficult and expensive. Revenue bonds will be unaffected by the recent constitutional amendments. Imposition of user charges do not require a two-thirds vote since they are not special taxes, and are unaffected by the Proposition 4 spending limit if they are not a substitute for other taxes and are used to pay for specific services. Debt servicing incurred for capital improvements seems to be reasonable costs of providing services, and debt service of revenue bonds are excluded from the spending limit. General obligation bond debt service is also excluded from the spending limit. But obvious increases in risk associated with all bonds will be reflected in higher interest rates. Also, repayment by local entities must be within their spending limits unless the debt is approved by the voters. Even if the voters should approve--and general obligation bonds require a two-thirds vote--bondholders must rely on an apportionment of property tax which is a legislative formula that can be changed in the future, and on other types of tax revenues that may not be as dependable as revenues from the property tax.

It is too early to predict how heavily local governments will rely on user charges. Under Proposition 4 there would seem to be a large incentive to use user fees for many services and free general tax financing for other uses. There is some evidence that local governments are raising fees and expanding their use. However, total revenue for a jurisdiction cannot be increased, since the spending limit must be reduced if a user charge is substituted for a tax.

A move to user charges, however, does have advantages in the following situations:

- if the costs of providing the present level of services will rise;

- if a higher level of services is to be provided at increased cost; or

- if new areas are to be serviced.

This is because a move to user fees will permit local governments to increase total revenue since the spending limit is adjusted dollar for dollar only on the substitution date. Future increases in user charges will not cause a reduction in the spending limit, which changes only with inflation and population increase.

It is also argued that user charges result in more cost effective provision of services since it is easier for the taxpayer to see what

he is paying for. For example, Berkeley recently abolished a fire inspection fee for local businesses when it was pointed out that the inspections had not been carried out. User charges, however, may be more costly for nonbusiness purposes since they are not deductible under Federal and State income tax laws while property and sales taxes are.

The impact on land use of the recent amendments is not at all clear. Residential development that increases population will raise the spending limit. Commercial and industrial developments that increase tax revenues but not the spending limit may be of no advantage unless the voters have approved an increase in the spending limit. The costs of providing services to new residential developments will depend on the extent to which infrastructure costs can be loaded on the developments through fees, dedications and required improvements. The best approach for any jurisdiction to take in evaluating new development seems to be to use a case by case analysis, using such tools as ABAG's Cost Revenue Impact System (CRIS). In any case, the competition may shift from seeking rateables to maintaining the status quo if existing conditions generate revenues equal to the annual incremental increase in the spending limit.

Since general tax effort is a factor in the allocation of Federal revenue sharing funds, the result of lesser property tax revenues resulting from Proposition 13 and the less rapid rate of increase resulting from Proposition 4 means that California local governments will receive a smaller share of these funds than in the past.

Finally, whether local governments will become more efficient in the future through such mechanisms as contracting out service provision to private sector or non-profit entities remains to be seen. The provision of new services by contractors is obviously much easier to implement than the transfer of existing service provision from a local government unit to a contractor because staff have a vested interest in maintaining the function in their agency.

Local Government Strategies

If one accepts these conclusions, we can next speculate about how local governments will--or could--make funding decisions on water quality related issues. Seven major points emerge:

- Wherever possible, revenues from user and service charges will take the place of property taxes for funding local water quality management activities.

- Few special purpose districts supported by the property tax will be created, while many will likely be merged or abolished. The one possible exception to this generalization are assessment districts that provide benefits and/or services to individual property owners.

- Attempts will be made by the Legislature and local governments to shift a larger share of the local government tax burden back onto commercial and industrial property.

- Few attempts will be made to construct capital intensive facilities in the absence of a large Federal matching program because of the spending limit and the difficulty of selling bonds. For this and other reasons, Best Management Practices for erosion, sedimentation and surface runoff control will receive high priority.

- Proposals to institute new user and service fees or use property tax revenues for water quality management activities will have to have broad local support and well developed technical justification. The costs and benefits of control measures will have to be understood by locally elected officials.

- Efforts to reduce local government costs will mean that many alternative forms of service provision will be examined. Local governments will look at organizing or expanding their own service, purchasing the service from another jurisdiction, entering into a joint management agreement with another jurisdiction, participating in a special-purpose government district, or buying the service from a private firm or non-profit entity.

- Service provision which have been viewed as the responsibility of local government will in some cases be shifted back onto the property owner, individual citizen, or community groups.

Possible Fiscal Responses

Increasingly the goals of local service provision by cities and counties will be to shift costs to the regulated or benefiting party, minimize costs of existing or new programs, provide the service as efficiently as possible, or let some other entity provide the service. The financing opportunities available to local governments can be broken down three ways:

- Capital costs for facilities

    a. General obligation bonds
    b. Revenue bonds
    c. Assessment bonds
    d. Promissory notes
    e. Contributions
    f. Lease-purchase agreements
    g. Connection charges
    h. Standby charges
    i. User charges
    j. Ad valorem taxes
    k. Wastewater capital reserve fund

- Operation and maintenance cost for facilities

  a. User charges (gate fees, service charges, effluent charges in a variety of ways)
  b. Permit charges
  c. Interest earnings
  d. Fines
  e. Ad valorem taxes
  f. Wastewater capital reserve fund

- Planning and regulatory program costs

  a. Ad valorem taxes
  b. Permit charges
  c. User charges
  d. Fines

The analysis of funding techniques for capital expenditures is presented in Appendix A. The rest of this paper discusses three likely responses that local governments might take:

- Institute new or expanded fees and user charges
- Develop better justification for Best Management Practices
- Investigate new forms of service provision

A proposal to use special assessment districts for the management of erosion and sedimentation on rural lands is presented in a separate memorandum.

IV. USER FEES AND CHARGES

Erosion and sedimentation control seem a likely candidate for expanded use of fees and charges. At the present time local governments' erosion control enforcement activities (project review and approval, site inspection, etc.) can be paid for out of general funds and permit fees. For the construction of erosion control facilities by a public agency Federal, State and local funds may be used for public projects and assessment fees may be used for private projects. The operation and maintenance of erosion control facilities by a public agency can be paid for out of assessment fees and cash deposits made by the developer. Clean-up activities for public projects can be paid for out of Federal, State and local funds, and by performance bonds and fines for private projects.

Erosion, sedimentation and stormwater runoff related to construction activities are usually controlled by cities and counties in the Bay Area through administration and enforcement of local grading ordinances. These ordinances generally provide that for grading activities greater than some specified minimum,the developer or landowner must devise a grading plan, seek a grading permit, perform the operation in a relatively regulated way--and possibly even post a bond which the local government can use to correct violations if the work is not undertaken in a satisfactory manner. Almost all local governments in the region use some form of local

grading ordinance.*

One feature of an effective grading ordinance is that grading permit/filing fees are gauged on full cost recovery of all processing, plan checking, inspection and other expenses of the administering agency. When a grading permit is issued, it is also recommended that a surety bond, cash bond or letter of credit is required, and procedures for its use are set forth in the ordinance.

An August 1979 survey of development fees in the Bay Area carried out by ABAG revealed that the median fee for a grading permit for 100 cubic yards of grading is $21, with a low of $8 and a high of $300. One jurisdiction includes the cost in its plan check fee, and one includes it in a single $250 site development fee. One jurisdiction charges a percentage of the cost of grading, while another charges a percentage of the improvement.

A survey of erosion control permit fees carried out across the country by Environmental Protection Agency staff in September 1979 showed that there are a wide variety of fee structures. At the low end, Frederick County, Maryland charges $2.00 a permit for plan review. Anne Arundel County, Maryland, charges a sliding fee based on the grading and erosion control costs. It is $10.00 for costs less than $500.00, $25.00 for costs in the $500.00 - $1,250 range, and $25.00 plus 2 percent of costs between $1,250 and $5,000.

The State of Pennsylvania recommends a $200.00 fee State-wide. Bellevue, Washington charges $20.00 for projects of less than 1 acre, $50.00 for projects of 1 to 5 acres, and for larger projects, $10.00 an acre and $15.00 an acre wherever impervious areas are to be created.

Dover, New Jersey charges $25.00 an acre or part thereof for a permit. Englewood, Ohio sets each fee individually by resolution of the City Council. El Paso, Texas has a minimum fee of $25.00, charges $10.00 an acre up to 50 acres, $8.00 an acre up to 100 acres, $6.00 an acre up to 500 acres and $4.00 an acre above that. Prince Williams County, Virginia has a fee of $25.00 plus $5.00 per acre of land disturbed.

Honolulu, Hawaii bases its grading permit on the volume of material moved. The fee is $5.00 for each 100 cubic yards up to 1,000 cubic yards, $50.00 for the first 1,000 cubic yards and $5.00 for each additional 1,000 cubic yards or fraction thereof. Above 10,000 cubic yards the fee is $95.00 for the first 10,000 cubic yards and $3.00 for each additional 1,000 cubic yards or fraction thereof. There are also separate permits for grubbing and stockpiling.

In California, EPA found that Los Angeles charges a plan review fee of $20.00 for the first 10,000 cubic yards of material moved an $10.00 for each additional 10,000 cubic yards or fraction thereof. There is also a separate inspection fee which is based on excavation costs:

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*For more detail see: "Water Quality Management Plan Grading Ordinances and Surface Runoff Control," ABAG Water Quality Technical Memorandum No. 34, October 10, 1979.

Excavation Costs	Fee
0 - $5,000	8%
$5 - $15,000	6%
$15 - $35,000	4.5%
$35 - $65,000	3.5%
$65,000 or over	2.5%

Locally, Contra Costa County charges a filing fee of $10.00 plus 5 percent of the cost of performing the work, excluding retaining walls, drainage facilities and offsite transportation. Under certain supervised conditions the permit fee is reduced to 2 percent.

The ABAG survey showed an extremely wide variation in local government fees for residential and commercial construction. For example, total development fees for a seven unit multi-family dwelling range from a low of $982 to a high of $25,482 across the Bay Area.

Many cities have increased their fees in an attempt to compensate for the loss of property tax revenues or General Fund revenues that occurred after the passage of Proposition 13. Some fees have been doubled, or even tripled, and new fees (such as "bedroom taxes" and school impact fees) have been adopted. School impact fees in particular are being considered by a number of cities facing the prospect of overcrowded classrooms. Many cities have adopted some form of pay-as-you-go policy to cover the cost of development-related services. A typical example of the direction cities are headed occurred in a city which raised its fees in 1979 to cover 50% of the costs associated with planning services. This same city is now considering raising its fees to cover all of its planning costs. Other cities have already raised their fees to cover total current operating costs. One city has been able to pay for some advance planning out of its new fees, which have been designed primarily to affect large developers.

No single criterion or methodology has been used by Bay Area cities in setting new rates after the passage of Proposition 13. Many cities have raised fees by, for example, doubling their existing rates. Other cities, however, have instituted a "time and materials" or "staff time" charge. In this system, the fee is based upon the length of time the job takes to complete, at a rate of from $15 to $32 per hour. This method is most likely to be used for reviewing an Environmental Impact Report (EIR) document and for checking final subdivision maps, although some cities have instituted it for a great many more of their development-related services.

The conclusions that can be reached reviewing these two surveys are that grading ordinance fees and related erosion control fee structures are very diverse, fairly arbitrary, and probably not keeping up the inflation in housing costs. They therefore seem like fees that can be increased as long as a link to the level of service provided is maintained.

Remaining questions are how much the fees can be increased and how areawide or Statewide regulatory consistency can be maintained. On the latter point, New Jersey's experience is worth reviewing.

The approach New Jersey has adopted for financing the administration of a soil erosion and sedimentation program is being recommended by the National Association of Conservation Districts for application in other parts of the country. In 1974 legislation was introduced in the New Jersey Legislature mandating erosion control throughout the State. The original draft included several options for home rule enforcement ranging from total soil conservation district enforcement to municipal exemption from district jurisdiction with State approval of municipal ordinances. It also included substantial State funding to get the program started. The measure became law in 1975 after the deletion of the State funding provision.

The key regulation in the law is that no municipality may grant approval of an application for development for any project until a plan for soil erosion and sediment control has been certified by the soil conservation district. A project is defined as the disturbance of more than 5,000 square feet of land for the accommodation of construction for which the State Uniform Construction Code would require a construction permit. Single family homes not part of a development are exempt.

Upon receipt of a complete application for certification of a soil erosion and sediment control plan, the conservation district--or municipality--must respond within thirty days indicating that the plan is (1) certified as meeting the State Standards as submitted; (2) certified with conditions or (3) denied with reasons stated. If no action is taken by the district within thirty days, the plan is automatically certified. The thirty day period may be extended for an additional thirty days by mutual agreement between the district and the developer.

The district is authorized to collect a fee from the applicant to cover the costs of providing services. The district fee schedule must be approved by the State Soil Conservation Committee prior to its implementation and must bear a reasonable relationship to the costs.

From January 1, 1976 to June 30, 1979, 6,387 applications were received Statewide. Averaging 10 acres each, these projects have involved approximately 64,000 acres of land to be developed. Sixty-one hundred and seventy-two projects were certified as submitted or with conditions with 221 rejected as inadequate. Over 1½ million dollars have been received in fees to cover costs. The average fee per application was about $200 or about $20 per acre. The activity among 16 districts has ranged from 1,100 applications in the Freehold district to 25 in the Salem district during the 3½ year period.

In 1975 most of 16 conservation districts had one full or near full time clerical person and one professional administrative person. These personnel were supported primarily by State funds administered by the State Soil Conservation Committee. Clerical personnel were employed on an hourly basis by the State and State matching funds were provided to support district level employment of the administrative personnel. Additional professional and technical personnel have now been employed directly by the districts bringing field strength to about 50.

Fees received under the program now total about $450,000 per year. State support is approximately $250,000 per year with county government contributions approximately $150,000 annually for a total district level budget of about $850,000 per year. This shows considerable public subsidization of the program with fees supporting a little more than half of the overall district operation. Estimates of districts' time spent on the urban erosion control program range from 10% to 90% with an estimated average of 75% Statewide.

The reaction to the new regulations from the public has been reluctant but, in general, compliant. Most developers have accepted the erosion requirement and include control plans without coercion. The home rule option was exercised by 85 municipalities which adopted ordinances meeting the approval of the State. The program seems to be successful, although there have been inevitable problems of a financial, technical and legal nature. A central concern is the level of State support for the program. While the fee structure seems to cover most local regulatory costs, funding for a State level appeal process is tenuous as is the availability of legal assistance from the Attorney General. There is also a need for reasonable assurance of maintenance of a basic State technical staff to assure reasonable Statewide uniformity and that adequate public accountability exists. State level monitoring of program effectiveness has also not been funded to date.

V. DEVELOPING BETTER COST ESTIMATES

The costs of implementing erosion and sediment control measures have been detailed in various EPA reports, but need to be refined and updated. The standard reference is "Comparative Costs of Erosion and Sediment Control Construction Activities," produced by EPA in 1973.* The cost estimates, which are for the Occoquan Creek Basin in Virginia and the Walnut Creek Basin in the Bay Area, can be updated fairly easily to consider inflation. However, the report's author--Bob Thronson--now believes that the cost figures for California should be "much less" than indicated. In the document the same BMPs for controlling sediment are used in California and Virginia. He believes the California site should have a system of BMPs designed specifically for the runoff, slope, soils, and other site-specific conditions and that these BMPs would be less costly than in the Virginia example.

Unfortunately, the costs for implementing surface runoff control measures in urban areas are harder to determine. A rough methodology for determining costs for street sweeping, catch basin cleaning for unswept areas and areas covered by street sweeping, sewer flushing and estimates of capital and O&M costs for detention tanks and diversion berms** , but more detailed cost estimates are clearly needed. These estimates will be

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* U.S. Environmental Protection Agency, Comparative Costs of Erosion and Sediment Control Construction Activities, EPA-430/9-73-016, July 1973. Also see: U.S. Environmental Protection Agency, Methods to Control Fine-Grained Sediments Resulting from Construction Activity, EPA 440/9-76-026, December 1976.

**Dennis Athayde and Andre Walso, "The Urban Stormwater Runoff Presentation," Nonpoint Source Branch, Water Planning Division, U.S. Environmental Protection Agency, Spring 1977.

developed under EPA's National Urban Runoff Program (NURP). They will be available in 1982 at the earliest!

This lack of information is particularly disappointing because fee structures for surface runoff controls are not practical since a large percentage of the impervious services in urban areas are in public ownership. There is some possibility that runoff taxes might be developed for private lands with a significant amount of impermeable surfaces, but none have been suggested to date.

VI. CONTRACTING ALTERNATIVES

Although contracting out governmental services is not a fund raising mechanism, it is a method of reducing local government costs that is receiving a great deal of attention. Indeed, the most frequently cited reason for contracting of public services is cost reduction. In the case of smaller jurisdictions, for example, contractors can frequently perform a service at lower cost because of what economists call "economies of scale." This means that when a single organization performs a service on a broad scale the cost per unit is lower.

Contracting for public services is important because it provides a viable alternative to direct delivery of services. In the private sector, companies change their methods of production, invent new products, and develop new ways of cutting costs and improving productivity because of the competitive pressures that exist in the private market. In the public sector there has traditionally been no competition because there have been no alternatives to direct delivery of services.

Contracting, then, should be viewed as one of several alternatives available to local governments in the provision of public services. In a national study of private contracting by local governments in 1974, the Urban Institute found that in many cases it is more important to have the ability to contract for services than to actually contract. In several communities where studies found that private contracting would produce major cost savings, the public agencies responded almost immediately with significant gains in productivity. The existence of alternatives produced the same type of competitive incentives that characterize most private sector industries.

In addition to cost, the arguments for contracting include:

- Limits the growth of government
- Avoids large start-up costs
- Permits greater flexibility to adjust program size
- Provides specialized skills
- Provides a yardstick for comparison
- Promotes increased objectivity by separating operation and evaluation
- Produces better management information because of contractual arrangements
- Produces better management by separating monitoring from operations
- Less expensive labor force
- Reduced overhead costs and procedures

Although there are a number of disadvantages to contracting, such as the tendency of contractors to cut corners, it is likely that Bay Area local governments will give much more attention in the future to purchasing services--either from other governments or from the private sector. Anticipating this trend, ABAG hopes to initiate shortly a six-month study of contracting alternatives for local governments.

APPENDIX A

THE ASSESSMENT OF THE FISCAL IMPACT OF SURFACE CONTROL MEASURES ON LOCAL GOVERNMENT*

* This material is derived from "Surface Runoff Assessment Procudures Manual," Association of Bay Area Governments, 1977.

Introduction

The implementation of control measures for the reduction of surface runoff pollution will probably create fiscal effects on local government. This chapter is designed to assist in the identification of the fiscal impacts of control measures.

The exact nature of the fiscal impact will obviously depend on the type of control measure. For example, the construction of redesigned curbs and gutters may involve only capital costs. The local jurisdiction might choose to cover these capital expenditures by issuing general obligation bonds or using cash reserves. The different financing methods would have very different fiscal impacts.

Alternatively, a control measure (e.g., cleaning the storm drain system) may generate only operating costs for labor and supplies. A jurisdiction could decide to raise the property tax rate, increase revenues received from permit fees, or create a special assessment district. Again, the fiscal impacts would depend on the specific mechanism for financing the control.

The method of implementing a single control measure may affect the nature of the fiscal impact. For example, the adverse water quality effects of dog litter may be reduced through a program of public education to aquaint dog owners with the problems caused by the droppings. Such a program would require some public expenditure to reduce pollution from dog droppings. The public education program would achieve the desired end with a net cost.

However, the jurisdiction could choose to reduce pollution from dog litter by increasing the fees for registering pets and establishing fines for failure to register the animal. In addition, citations (similar to parking tickets) could be issued to people who allow their dogs to roam without a leash or eliminate on a public street. This method of implementation would cause increased expenditures for enforcement, but it would also generate increased revenues from fines and fees. In this case, it is likely that the additional revenues would more than offset the extra cost. Thus, the pollution from dog droppings could be reduced with a net revenue.

Assumption

Throughout the assessment of the fiscal effects of surface runoff controls on local government, it must be assumed that Federal and State grants will not be provided for facility construction or program implementation. This assumption may prove false; Congress or the Legislature may establish assistance programs for the implementation of surface runoff controls. However, the assumption is necessary to assure that the full extent of the local fiscal impact is revealed. For the assessment of the full impact, it must be assumed that local governments will have to fund local programs entirely from local revenues.

Fiscal Effects on Local Government

- o Impact on general obligation, revenue, or special assessment bonds and bonding capacity.

Background:

Local governments generally pay operating and maintenance expenses from current revenues. However, capital investments are often funded from the proceeds of the sale of bonds. Indeed, bonded indebtedness is the major source of revenues for financing capital improvement projects.

There are three general types of debt instruments which can be used to finance the implementation of environmental management plans. Two of these instruments, general obligation bonds and assessment bonds, use the property tax as a source of debt service funds. The third type of debt instrument, revenue bonds, are guaranteed by revenue producing enterprises.

General obligation bonds guarantee the "full faith and credit" (unlimited property taxing authority) of the issuing jurisdiction for payment of the debt. Because of the relatively high degree of security and favorable tax incentives, the interest rate or cost of debt service on general obligation bonds is usually less than other types of bond instruments.

Another type of debt financing, which relies on property taxes for payment, is assessment bonds. Assessment bonds extend the capital cost of the project over the area benefited by the project. A special assessment district is created and each land parcel is assessed a pro rata share of the bonded debt. In California there are two types of assessment bonds:

(1) 1911 Act Bonds -- Bonds are issued against specific parcels for the amount of the debt or assessment on that parcel. Billings for retirement of the debt (principle and interest) are sent to each parcel owner. The City or County treasurer transmits the revenues to the holder of the bonds. In case of default, the bond holder is allowed a recourse similar to mortgage foreclosure.

(2) 1915 Act Bonds -- These are serial bonds issued against the entire assessment district. Bills for payment of principal interest are included with the regular tax bill for each property owner rather than being mailed separately. However, the annual assessment bond payment is a flat fee and not part of the general property tax rate. The remedy for default allows city or county officials to sell delinquent properties. If the funds from such sale and other resources are insufficient to retire the debt, the jurisdiction is required to levy a tax of up to \$.10/\$100 A.V. per year on the assessed evaluation throughout the city or county to meet the delinquency.

Revenue bonds, which do not depend on the tax base, can be issued for the financing of revenue producing enterprises. These bonds may be secured only by the revenues from the enterprise. In some cases, the bonds may include a partial jurisdictional guarantee through a lease arrangement with the city or county. The bonds are guaranteed to the extent that the jurisdiction is required by the lease agreement to make annual rental payments to the revenue enterprise.

The amount of general obligation debt that any single jurisdiction can incur is subject to some limitations. The specific limit depends on the type of jurisdiction and the type of project funded by the general obligation bonds. The debt limit for general law cities and counties is 5% of the total assessed valuation of the jurisdiction. This debt limit can be raised to 15% of assessed value, if the project includes development of water, sewer, irrigation systems, and special roads. Charter cities and counties are allowed to establish their own debt limit.

The debt limit for special districts varies depending on the type or purpose of the district. Park and Recreation districts cannot issue bonds which exceed 5% of the assessed valuation of the district. Certain types of special districts (e.g., municipal utility districts or community service districts) may issue bonds for up to 20% of the assessed value of the district. Other types of districts (e.g., water districts or sanitation districts) have no limit on the bonds that may be issued except for the willingness of the voters to approve such issues.

Although interest on assessment and general obligation bonds is limited to 8%, the bonds can be sold at less than par or face value to make them marketable. Effectively, the bond price is discounted to raise the yield to the investors thus making the bond more competitive with other types of investment opportunities. However, this raises the cost of financing since more bonds must be issued to yield the capital required for the project.

Impact Questions:

Will general obligation bonds be issued to finance projects required by alternative plans?

Will these general obligation bonds be issued by only certain identifiable jurisdictions?

What is the anticipated cost of debt service for the general obligation bonds to be issued?

Note: This impact should be expressed in annualized total cost and the amount of increase in the property tax rate.

What is the impact on bonding capacity for each jurisdiction?

Note: The bonding capacity is the difference between the total amount of outstanding general obligation bonds and the debt limit for the specific jurisdiction.

Will assessment bonds be issued to finance alternative plans?

Can the issuing assessment districts be identified?

Will new assessment districts be required?

What is the anticipated cost of debt service on these assessment bonds?

Will revenue bonds be issued to finance alternative plans?

What is the anticipated cost of debt service on the revenue bond?

What are the projected revenues from the project(s) constructed under the plan?

Will the project qualify under existing State or Federal grant programs which would reduce the need to issue bonds?

Note: It should be assumed that no new grant programs will be authorized. Furthermore, it should be assumed that the qualifications for existing programs will remain unchanged.

Will the project qualify for State or Federal loans or loan guarantees?

Information Sources:

County assessors, city and county tax collectors, treasurers or finance officers.

County Tax Rate Book (printed annually for each county).

California State Controller, *Annual Report of Financial Transactions Concerning Cities of California*.

California State Controller, *Annual Report of Financial Transactions Concerning Counties of California*.

California State Controller, *Annual Report of Financial Transactions Concerning Special Districts of California (other than water utility*.

California State Controller, *Annual Report of Financial Transactions Concerning Water Utility Operations of Special Districts of California*.

Fiscal Effects on Local Government

- Impact on property tax base.

Background:

The basis of the property tax is property. For any city, county or special district, the property tax base is the assessed valuation of the jurisdiction. In California property is taxed according to provisions of Article XIII of the Constitution of California. This provides that "[a]ll property in the State...shall be taxed in proportion to its value...." The Article defines property to include "monies, credits, bonds, stocks, dues, franchises and all other things real, personal and mixed capable of private ownership...."

In California the property tax base can be classified into two categories: secured and unsecured. The secured tax base is the real property including land and improvements. The unsecured property tax base is the personal property of individuals residing in the jurisdiction. Effectively, the unsecured property tax is a levy on the tangible business property including equipment and inventory. However, when a business enterprise owns the land on which the business is conducted, the inventories, fixtures, machinery, office furnishings and other property is considered to be part of the secured tax base because it is "secured by the land."

In California the tax base or assessed value should be 25% of the fair market value of the property. (The Property Tax Relief Act of 1972, known as SB 90, made several changes in the California property tax financing including a 50% exemption on the full market value of business inventories.) The fair market value estimates are based on the present market selling price as determined by recent sales of comparable properties. However, because of inflation or rising property values and the County Assessor's practice of periodic reassessment, the assessed value will often be somewhat less than 25% of the market value. In 1975-76, the statewide average for assessed value was 24.7% of the full market value.

Surface runoff control measures can increase the property tax base in two ways. First, control measures could impact the secured property tax base by imposing development restrictions which affect the price of property in the entire market or by requiring improvements which increase the market value of specific properties. For example, the construction of roof-top storage facilities on factories could increase the market value of the property. If the cost of the storage were 2% of the cost of the factory, the market value and consequently the assessed value could be expected to increase by a similar percentage.

The second method of increasing the property tax base is through the impact of control measures on unsecured property. Surface runoff controls might necessitate business investment in new equipment or fixtures. The assessed value of this new equipment would become part of the property tax base. Again, the assessed value would be expected to increase in proportion to the relative cost of the new and existing equipment and fixtures.

Implementation of control measures may also cause decreases in the property tax base. The tax base may be decreased directly through public condemnation action (eminent domain) to secure property for public improvements. In this case the decrease would be equal to the assessed value of the land and improvements.

The property tax base may be decreased indirectly by controls which create disincentives for future capital investment. In this case, control measures which made future property development or business investment substantially more expensive would tend to reduce anticipated development and investment and slow the historic rate of increase in assessed valuation. However, this indirect or synergistic effect will be difficult to estimate.

Impact Questions:

Will control measures affect the value of secured property?

Can the specific types of affected land uses be identified?

Will control measures affect the assessed value of unsecured property?

Can the specific types of affected businesses be identified?

Information Sources:

California State Board of Equalization, California State Board of Equalization Annual Report.

U.S. Department of Commerce, Bureau of the Census, County and City Data Book, 1972. Washington, D.C.: U.S. Government Printing Office, (1973).

California State Controller, reports previously cited.

California State Controller. Assessed Valuation and Tax Rates of the Counties of California. (Annual)

Assessment information from housing supply criteria.

Fiscal Effects on Local Government

- Impact on property tax rate

Background:

The property tax is the single largest source of revenue for local governments in California. Cities, counties, school districts and most other special districts levy a property tax on both secured and unsecured property. Some special districts tax only real property and certain of these restrict their levy to only the value of the land. Property tax assessment and collection are generally county functions. However, there are two cities in the Bay Area (Alameda and Piedmont) which collect their own property tax.

The Property Tax Relief Act of 1972 (SB 90) placed limitations on the ability of local governments to raise revenue through increases in the property tax rate. The Act limited taxing jurisdictions from raising the property tax rate without voter approval. Each jurisdiction had a choice of using either the 1971-72 property tax rate or the 1972-73 rate as their maximum. Absent voter approval, a jurisdiction could not raise the property tax rate above this limit. However, there are several exceptions to the general rule which allow the property tax rate to exceed the limit in certain situations. The tax rate may be raised to pay debt service or retirement benefits that have been approved by the voters. The tax rate may also be raised to cover the cost of activities mandated by either the Federal government or the courts. In addition, the tax rate may be raised if increased property tax revenues cannot keep pace with increases in the jurisdiction's population and increases in the cost of living.

Two additional exceptions to the SB 90 limit are allowed for emergency situations. After defining a specific emergency situation, the city or county may increase the maximum rate 1% for one year with a vote of 4/5 of the governing board. Alternatively, the board may ask the Governor to declare a "dire emergency" and, following public inquiry, the State controller may declare an emergency tax rate.

Historically, impacts on the property tax rate could be easily estimated. The cost of new projects or programs not covered by other revenue sources would be divided by the assessed valuation of the jurisdiction. This would yield the net change in the property tax rate. Now, however, the analyst must check the tax rate limit and in some cases, exceptions to that limit in determining the impact of control measures on the property tax rate.

Impact Questions

Will control measures necessitate an increase in revenues from the property tax?

Will increasing assessed values be sufficient to meet new property tax revenue requirements without tax rate increases?

Will the new property tax rate exceed the maximum limit?

Is the new tax rate allowable under the legislated exceptions to SB 90?

Information Sources:

California State Controller, Division of Local Government Fiscal Affairs. Report of Budget Requirements and Means of Financing Adopted by California Counties.

County Assessor's Office "County Tax Rate Book" (published annually in each county).

Fiscal Effects on Local Government

o Impact on sales and other taxes

Background:

Retail Sales Tax

A local retail sales tax of 1% is collected by the State of California and rebated to the city in which the sale takes place. If the retail sale is made in an unincorporated area, the sales tax revenue is rebated to the county. In addition, over half of the California counties have agreements with their cities whereby negotiated portoins of the sales tax collected in a city is shared with the county.

The amount of revenue from sales taxes is directly determined by the amount of taxable sales in a jurisdiction. However, taxable sales are affected by several factors including the quantity and attractiveness of retail facilities, the number of shoppers, and their incomes and expenditure patterns.

Retail sales tax revenue is not directly related to population since the revenue is returned to the site of the sale. This results from differential levels of per capita retail sales among communities which is not necessarily related to differential income levels of each community's residents. Generally, however, retail sales tax revenue for any jurisdiction will be effected in two ways. First, increases (decreases) in population or personal income will cause increases (decreases) in expenditures for taxable items. For small changes, this can usually be assumed to be a direct linear relationship.

Second, openings of new sales outlets can often increase sales tax revenue by attracting customers and consequently taxable purchases from neighboring jurisdictions. The degree to which businesses in one jurisdiction can attract customers from another jurisdiction is often referred to as the capture rate. However, new commercial facilities alone may not increase sales tax revenues. If a new shopping center attracts customers from existing downtown shopping areas, without increasing overall sales, the revenue from sales taxes to the jurisdiction will remain unchanged.

Property Transfer Tax

The property transfer tax applies to sales of real property, including land and improvements. Since 1968 this tax has been available to cities and counties in California. The tax is levied at the rate of $1.10 per $1,000 sale value of the property transfer. However, the taxable sale value is exclusive of any lien or encumberance on the property.

If the site of the sale lies within a city which has enacted the tax, the proceeds are shared equally by the city and the county. If the site of the sale lies within an unincorporated area, the entire revenue from the property transfer tax accrues to the county.

Revenues from the property transfer tax may be impacted by changes in the number of property transfers or changes in the sale value of the property.

Vehicle Code Fines

Vehicle code fines provide a restricted revenue source for local governments. Monies from fines and forfeitures as a result of vehicle code violations may be used only for "traffic signs, signals, other traffic control devices, the maintenance thereof, equipment and supplies for traffic law enforcement and traffic accident prevention, and for the maintenance, improvement or construction of public streets, bridges and culverts..., but such fund shall not be used to pay the compensation of traffic or other police officers."

The allocation of vehicle code fines between state, county and city will vary. Most of the revenue from fines for citations issued within a city will go to that city. However, a small percent (20 to 30) will go to the county to defray court costs. The actual percentage of this shared revenue is subject to agreement between the city and the county. Revenues from citations issued in the unincorporated area go entirely to the county.

Revenues from vehicle code citations are generally responsive to changes in population. However, it is not a simple linear relationship. Average per capita vehicle code fines in any city increase as the population of the city increases. For small cities (under 5000 population), per capita vehicle fines average less than one dollar per year. For cities between 50,000 and 100,000 population, the average is 3 to 4 dollars per capita. For older or larger cities, other factors become important such as the age of the city, the conditions of the streets, traffic, parking problems and other factors including vehicle code enforcement.

For both cities and counties, the most accurate way to estimate changes in revenues from vehicle code fines will be on the basis of population. However, factors like construction of new roadways or changes in a number of private vehicle trips will effect this general estimate.

Utility Franchise Tax

Cities may impose a tax on utility operations. The tax may either be imposed on utility service itself or on the consumers of that service. The utility tax is usually levied as a percentage of the total utility charge. In most jurisdictions the tax is applied to natural gas, electricity, and telephone services. In some instances, cable television services are also taxed.

Revenue from a utility tax are based on the consumption of the taxable utility services, the charge for the service, and the tax rate. Typically, the utility tax rate is 5% of the billing charge. Utility charges differ among categories of consumers as well as utility companies and type of energy. Charges generally decrease on an incremental basis. The more a particular consumer uses a utility the less they will pay per unit.

Consumption of taxable utility services can be projected on basis of the number of households in the jurisdiction and average household consumption. Increases in commercial and industrial consumption can be estimated on the basis of the historic ratio of commercial and industrial growth to residential development unless obvious conditions intervene to change these factors.

Transient Occupancy Tax

The transient occupancy tax is levied at the discretion of cities and counties on consumers of lodging services in their jurisdictions. Most commonly a rate of 5% of the lodging price is imposed. However, the tax does not apply if the period of occupancy is longer than 30 days.

The revenue from transient occupancy taxes can be effected in three ways. First, revenues to a jurisdiction can be expected to increase if the vacancy rates at lodgings within that jurisdiction decrease. Second, revenues will generally increase in response to increases in the number of hotel and motel rooms available within a jurisdiction. Finally, because the transient occupancy tax is a direct function of the cost of lodging, revenues will increase in response to increases in the average cost per room.

Impact Questions:

Will control measure(s) implementation within any jurisdiction cause:

changes in the disposable income of families in the jurisdiction?

changes in the ratio of taxable and non-taxable purchases?

changes in the captured rate of taxable purchases from outside the jurisdiction?

changes in the number of property transfers?

changes in the sale value of property?

changes in private vehicle use?

changes in traffic congestion?

changes in parking regulations?

changes in traffic patterns or road conditions?

changes in the enforcement of existing vehicle code regulations?

changes in average household utility consumption?

changes in commercial or industrial utility consumption?

changes in utility rates?

changes in the number of households?

changes in the occupancy rate of transient lodgings?

changes in the number of transient lodging units?

changes in lodging rates?

Information Sources:

California State Board of Equalization. Taxable Sales in California, published quarterly. (Detailed breakdown of sales in small area studies are available from the State Board of Equalization.)

U.S. Department of Labor, Bureau of Labor Statistics, "Annual Consumption Costs for Urban Family of Four", published Autumn '72.

Urban Land Institute, The Dollars and Cents Shopping Centers. 1972.

U.S. Department of Labor, Bureau of Labor Statistics. Three Budgets for an Urban Family of Four Persons, 1969-70, Bureau of Labor Statistics Supplement 1570-5.

State of California Controller reports, previously cited.

U.S. Department of Commerce, Bureau of the Census. County and City Data Book, 1972.

State of California Energy Commission. Fuel and Energy Summary (Volume 2 contains first and second quarters of 1976, third and fourth quarter information should be available soon.)

State of California Energy Commission, Energy Forecast and Planning Report, September, 1976.

Pacific Gas and Electric Company. Econometric Model and Forecast of Demand for Electricity, 1976-1995. (20-year energy forecast filed with Energy Commission 9 August 76 in compliance with Section 25300 of the Public Resource Code.)

State Board of Equalization, Statistical Research and Consulting Division. Data for Estimating Local Sales Tax Revenues and Cigarette Tax Subventions.

Fiscal Effects on Local Government

- Impact on fees, licenses, and other user charges.

Background:

Business License Tax

Cities and counties in California may require a license tax from businesses which operate within their jurisdictions. The actual rate of this tax will vary among jurisdictions and types of business enterprises. The fee can be a flat amount for all businesses or it may be graduated depending on the size of the business. In the Bay Area business license taxes are typically computed on the basis of either gross receipts, gross payroll, the number of employees, the value added to the product, the cost of production factors, or simply a fixed rate. In cases of some special business enterprises, the business license tax may be computed on a factor that is specific to that business (i.e., tax on bowling alleys is often computed on the basis of the number of bowling lanes). Commercial and local-serving industrial development usually follow residential growth. Therefore, long term changes in revenues from business license fees will be related to population growth.

Development and Construction Fees

Private development of residential, commercial or industrial areas will cause public costs for the establishment of municipal services to the new developments. Cities and counties charge processing and development fees to offset the cost of providing these new services.

Each unit of local government has an itemized schedule of fees and charges for types of development within their jurisdiction. Generally, development fees associated with construction reflect the public cost incurred to review plans or to expand and connect various public services. However, the actual rate for these fees are specific to individual local governments.

Typical processing and development fees will include subdivision development fees, park dedication fees, fire protection and community facilities assessments, and school fees which are charged on a basis of the number of dwelling units or some equivalent in the development. Other fees include building permit fees, engineering inspections and utility permits which are charged on the basis of the total construction costs. Finally, fees like annexation assessments or drainage fees are charged on the basis of the number of acres developed.

Motor Vehicle License and Trailer Coach Fees

The motor vehicle license fee is an annual 2% tax on the market value for motor vehicles and trailers. A 2% tax is also levied on the market value of trailer coaches and mobile homes in the form of a trailer coach fee. Because tax is levied in lieu of a personal property tax on the vehicles this fee is referred to as the "In-Lieu" tax.

Revenues from the motor vehicle license fee and trailer coach fees are collected by the Department of Motor Vehicle at the time of vehicle registration. The revenues from these fees are deposited in the Motor Vehicle License Fee Fund

Local revenues from in Lieu taxes or gasoline sales (both the excise taxes and sales taxes) will be affected by control strategies which tend to reduce either the number of vehicles on the road or number of miles driven.

Cigarette Excise Tax

According to Section 30462 of the Revenue and Taxation Code, the cigarette excise tax is levied on all cigarettes sold in the State of California. The cigarette tax is 10¢ per package, based on wholesale distribution. It is collected by the sale of stamps or metered impressions to cigarette distributors. Revenues from the cigarette excise tax are distributed to the State Controller, to cities and counties, and to the State General Fund.

The local share of the cigarette excise tax is 30%. These local revenues are apportioned on the basis of the sales tax revenue distribution. Between all cities and counties the monies are divided in the same proportion that the local sales tax was distributed between cities and counties in the previous calendar quarter. Each county's share is paid in accordance with this distribution. Then the city's share of the cigarette tax revenues is divided in half. The first half of the revenue is distributed in proportion to relative local sales tax revenues of that city. The second half is distributed in proportion to relative populations.

Because of the taxing and distribution formulae, the cigarette tax revenue for any jurisdiction will depend on the statewide consumption of cigarettes and the relative local share of the State's sales tax revenues and population. However, changes in any of these factors are not likely to have a significant impact on local revenues since the cigarette tax represents approximately 0.85% of the revenues for local government.

Alcoholic Beverage Control Licenses

The State of California charges a fee for the issuance of alcoholic beverage control licenses. Liquor licenses are issued at various rates to manufacturers, wine growers, distributors and retailers of several categories. Fees from the original on-sale and off-sale licenses and license transfer fees are paid into the Alcoholic Beverage Control Fund. Monies deposited in the ABC Fund are available only for refund and transfer to the State General Fund. However, license renewal fees are also deposited in the ABC Fund from which only o0% is transferred to the General Fund. The balance is apportioned to cities and counties on a semi-annual basis. The apportionment to each city and county depends on the amount of fees collected in the city or the unincorporated areas of the county relative to the total fees collected throughout the State.

Local revenues from alcoholic beverage control license fees are not expected to be highly responsive to the implementation of surface runoff control measures unless major development occurs in a specific jurisdiction.

After deducting administrative costs for the DMV the remaining net revenue (except from trailer coaches) is apportioned 50% each to cities and counties. Revenues are divided between cities based on the proportion that the vehicle population of each bears to all other vehicles and are divided among counties in proportion to county population.

License fees paid on trailer coaches are apportioned to the county where the trailer coach is located. If the trailer coach is located in a city, the fees are divided with one-third going to the city and one-third going to the county. The remaining third of the trailer coach fee will go to the local school districts. If a trailer coach is located outside of the city, the school districts and county divide the money equally.

Highway Users Tax

Gasoline sales in California are subject to sales and excise taxes. A portion of the revenues from both of these taxes are distributed to local governments. Of course the sales tax is distributed in proportion to the gasoline sales within any jurisdiction. Revenues from the excise tax however, are returned to cities and counties on the basis of motor vehicle registration, assessed valuation, population, and maintained road mileage.

The State of California charges an excise tax of 7¢ per gallon of gasoline. Revenues from this excise tax are distributed to cities, counties and the State Highway Fund. According to Section 2104 of the Street and Highway Code, counties received 23% of the excise revenues ($0.01625 per gallon). Three-fourths of the Section 2104 revenues are apportioned among the counties in proportion to the average number of vehicles registered in each county. Some of the remaining Section 2104 revenues are allocated to counties for engineering, administration, snow removal costs, and heavy rainfall and storm damage. The remaining monies are allocated in proportion to the number of miles of maintained county roads.

Section 2107 of the Street and Highway Code allocates 10% of the highway users tax ($0.00725 per gallon) to cities within the State. Flat fees are allocated to cities for snow removal and road engineering and administration. The balance is apportioned among cities on the basis of the population that each city bears to the total population of all cities in the State.

Section 2106 of the Code allocates 15% of the highway users tax ($0.01040 per gallon) to both counties and cities. Under this section each county and city receives a flat monthly fee of $800 and $400 respectively. In addition, $30,000 is directed each month to the State Bicycle Lane Account. The balance of the revenues are then divided among the counties and the cities of the State by a three-step process. First, funds are divided among the counties on the basis of average motor vehicle registration. Second, in each county, funds are divided between the county and the cities in that county on the basis of assessed valuation. Finally, the revenues allocated to each county's cities are distributed among the cities according to relative population.

Section 2108 of the Street Highway Code allocates the remaining 52% to the Highway Users Tax or excise tax revenues ($0.03610 per gallon) to the State Highway Fund.

Parking Fees

Local governments also receive revenues from fees, licenses and other user charges assessed within the jurisdiction itself. Most cities receive fees from parking meters or municipal parking lots. Control measures which impose parking restrictions in order to improve the effectiveness of mechanical street sweeping operations will likely affect parking fee revenues.

Animal License Fees

City and county governments receive revenues from the issuance of licenses for domestic animals, usually dogs. The revenues from these fees are related to the number of dogs in the jurisdiction and the enforcement activity. It is estimated that in many parts of the Bay Area there are approximately 17 dogs for every 100 people; however almost half of these pets are unlicensed. Control measures designed to eliminate dog droppings on public streets are likely to affect animal license revenues in two ways. First, control measures could affect the number of dogs in the jurisdiction because people might recognize the pollution problem caused by dogs and choose not to have them as pets. Second, the implementation or enforcement of the pollution control measure could affect the ratio of dogs that are licensed.

In addition, municipalities often require registration of livestock and certain types of exotic animals that are maintained as pets within the jurisdiction. Surface runoff control measures could affect revenues from livestock and exotic animal fees in a manner similar to the fees from domestic animals.

Pesticide Distributor's License and Pesticide Tax

Counties in California receive revenue from the sale of pesticides and the licensing of pesticide distributors. Section 12841 of the Food and Agriculture Code imposes a tax of 8 mils per $1.00 on the sale of registered label pesticide materials; five-eighths of the revenues raised from this tax on the sale of pesticides is distributed among the counties. The apportionment to each county is in relation to the monies spent by that county on pest control and pesticide use management programs.

Section 12104 of the Food and Agriculture Code imposes a $50 license fee on all pesticide distributors. Half of the monies collected under the pesticide distributor's license fee are apportioned among the counties in relation to the relative number of pesticide distributors in each county.

Local revenues from the sale of pesticides and the registration of pesticide distributors may be affected by the implementation of surface runoff control measures. Controls which tend to reduce overall sales of pesticides and reduce the number of pesticide distributors will tend to reduce local revenues distributed under these programs. However, if pesticide use enforcement programs are increased disproportionately in urban counties for control of urban runoff, the revenues distributed from the sale of pesticides would tend to be increased in those urban counties.

Impact Questions:

Would the implementation of the control measure(s) in any jurisdiction have an impact on:

the number of business enterprises?

the number of employees?

the total amount of gross receipts?

the total gross payroll?

the total cost of production factors?

business license fee schedules?

residential dwelling unit construction?

commercial facility construction?

industrial plant construction?

the rate of land development?

the ownership of private vehicles?

the ownership of coaches and trailers?

gasoline consumption?

cigarette consumption?

the number of retail alcoholic beverage outlets?

the number of parking meters?

the number of spaces in parking fee lots?

parking rate structures?

the number of domestic animals?

the percent of domestic animals which are licensed?

the number of registered livestock?

the number of registered exotic animals?

the extension of registration requirements to other types of animals?

the amount of registered pesticide sales?

relative expenditures on pest control and pesticide use management operations?

number of pest control distributors?

Information Sources

City and County Tax Collectors, Chambers of Commerce,

City and County Engineers, Planning Department, Public Works Department, Building Department, .

State Department of Motor Vehicles, .

Alcoholic Beverage Control Board, .

County Animal Control Office, SPCA, .

City and County Treasurer; Division of Accounting, State Controller's Office.

California State Controller Report of Financial Transactions Concerning Streets and Roads of Cities and Counties of California.

California State Controller. Highway Users Tax Fund Apportionment (monthly)
California State Controller. Allocations to Certain Counties for Snow Removal and for Heavy Rainfall and Storm Damage. (Annual)
California Department of Food and Agriculture. Pesticide Use Report. (published annually).

California Department of Alcoholic Beverage Control. California Licensed Importers for Alcoholic Beverages. (Published annually; arranged alphabetically by County).
California Department of Alcoholic Beverage Control, Alcoholic Beverages Licenses.

California Department of Alcoholic Beverage Control. Licenses Automatically Revoked Under Section 24048.1 of the Alcoholic Beverage Control Act. (Published separately for both fiscal and annual years.)
Department of Motor Vehicles, "Statement of Transactions and Total Fees Collected" (monthly).

o Impact on Connection and Standby Charges.

Background:

Cities, counties and special districts, especially sewer and water districts, assess a hook-up fee on new developments for connection to existing public utility systems. Typically, sewer and water facilities are constructed to meet anticipated demand so that new facilities do not have to be built as each development occurs. However, the new developments must reimburse the local governmental unit for these expenditures in order to connect with the utility system.

The connection charges will vary depending on the type of governmental unit providing service and the type of service provided. Revenues from these connection fees are dependent on the fee structure and the rate of residential, commerical and industrial development in the jurisdiction. Control measures which affect the rate, timing and location of residential, commercial and industrial development will affect the revenues from these connection fees.

Recently, several jurisdictions have introduced standby charges for major consumers of public utility services. Typically, this takes the form of an industrial standby charge; an industrial user must "purchase" the capacity required from the sewer or water system. Generally, new industries are not charged interest on the plant cost until the buy-in date but the principal cost is based on the initial outlay for the facility. The rate of the fee is usually based on the estimated effluent volume. The schedules also include assessments for high-strength effluent or peak discharges.

Procedure:

Would the implementation of the control measure(s) in any jurisdiction have an impact on:

the rate or timing of residential development?

the rate or timing of commercial development?

the rate or timing of industrial development?

connection fee schedules?

the application of standby charges?

volume of industrial effluent?

the rate of the standby charge?

Information Sources:

Consult local officials and assessment information from urban patterns criteria.

Fiscal Effects on Local Government

- o Impact on Federal and State grant subvention funding dependance and eligibility.

Background:

State and Federal assistance generally takes two forms, categorical grants and block or entitlement grants. Categorical grants are tied to specific projects while entitlement grant funds may usually be spent for a variety of purposes.

In the last few years the Federal government has provided grant assistance to local, general and special purpose governments to control pollution. Many local governments have applied for and received monies from these categorical assistance programs, including: Construction Grants for Wastewater Treatment Works (EPA), Basic Water and Sewer Facilities Grants (HUD), and Water and Waste Disposal Systems for Rural Communities Program (USDA).

More recently, Congress approved the State and Local Fiscal Assistance Acts of 1972. Federal revenue sharing monies are distributed to local, general purpose governments through entitlements rather than by loca application. Local governments are allowed substantial discretion in how they choose to spend the money, and many have allocated funds to pollution control programs.

Throughout this assessment, it has been assumed that units of local government would not receive State or Federal grants for facility construction or program management to control surface runoff pollution. This assumption of no additional grants may not prove true in fact, but it provides a constraint which will reveal the full extent of the fiscal impacts on local governments.

Even with this constraint, new pollution control programs, such as surface runoff controls, may cause a shifting of Federal Revenue Sharing expenditures at the local level. Such shifting would likely increase the dependence of local governments in general, and local surface runoff control programs in particular, on Federal grant assistance. Thus, surface runoff control measures could have an impact on grant spending without necessarily having any effect on current levels of State or Federal assistance.

Despite the assumption that local governments will not receive additional State and Federal assistance, some surface runoff control strategies may be eligible for categorical grant funding. The assistance would come from existing types of categorical grants such as those mentioned above.

Impact Questions:

Would the implementation of the control measure(s) in any jurisdiction have an impact on:

expenditures from current or anticipated Revenue Sharing funds?

eligibility for additional State and Federal categorical assistance?

Information Sources:

U.S. President, Office of Management and Budget, Catalog of Federal Domestic Assistance, (Annual Report).

League of California Cities, Handbook for Planning and Managing Community Development, Sacramento, California: League of California Cities, 1974.

Association of Bay Area Governments, Financing Open Space for the San Francisco Bay Region, by Baxter, McDonald and Smart, San Francisco, California: 1973.

Association of Bay Area Governments, Federal Grant Study, Berkeley, California: 1975.

ABAG FAPRS (Federal Assistance Program Retrieval System).
Local Finance Officer or Budget Director.

Fiscal Effects on Local Government

- o Impact on Interest earnings and cash reserves.

Background:

In fiscal year 1973, local general purpose governments received approximately $240 million in investment earnings and interest income. This accounted for 1.6% of all local revenue (1.2% of county revenue, 2.3% of city revenues). Most of this income came from the interest on bank savings of cash reserves. Recently, with the advent of Federal revenue sharing, local government cash reserves and thus interest incomes have increased.

Since investment income is a direct function of the amount of capital invested, implementation of surface runoff control measures which necessitate expenditure of capital reserves will tend to reduce future interest earnings. The annual reduction in interest earnings will be equal to the product of the cost of the facility financed from reserve capital and the interest rate.

Impact Questions:

Would the implementation of control measure(s) in any jurisdiction have an impact on:

cash reserves?

investment principal?

interest earnings?

Information Sources:

City, county or special district, budget officer, finance director, controller, treasurer.

WQ/Tech Memo # 47
Kenneth Moy

WATER QUALITY MANAGEMENT PLAN

MODEL EROSION AND SEDIMENT CONTROL ORDINANCE

Technical Memorandum No. 47
April 28, 1980
Revised August 1980

INTRODUCTION

The Model Erosion and Sediment Control Ordinance, summarized in Table I.A.1, is to be used by local jurisdictions to evaluate the effectiveness of their present grading ordinances in controlling erosion and sediment from construction sites. Where inadequacies are found, the model should then be used to revise or amend the ordinances--or the entire model may be adopted as law.

The model ordinance is limited in scope. It addresses only questions of erosion and sediment control, as it is assumed that other provisions of local ordinances will deal with such questions as slope stability and safety.

In the text of the model, passages or blanks enclosed in brackets are intended to be modified or filled in by local jurisdictions. Substantial changes to other parts of the model should be carefully considered, for such changes may undermine the effectiveness of the regulatory scheme.

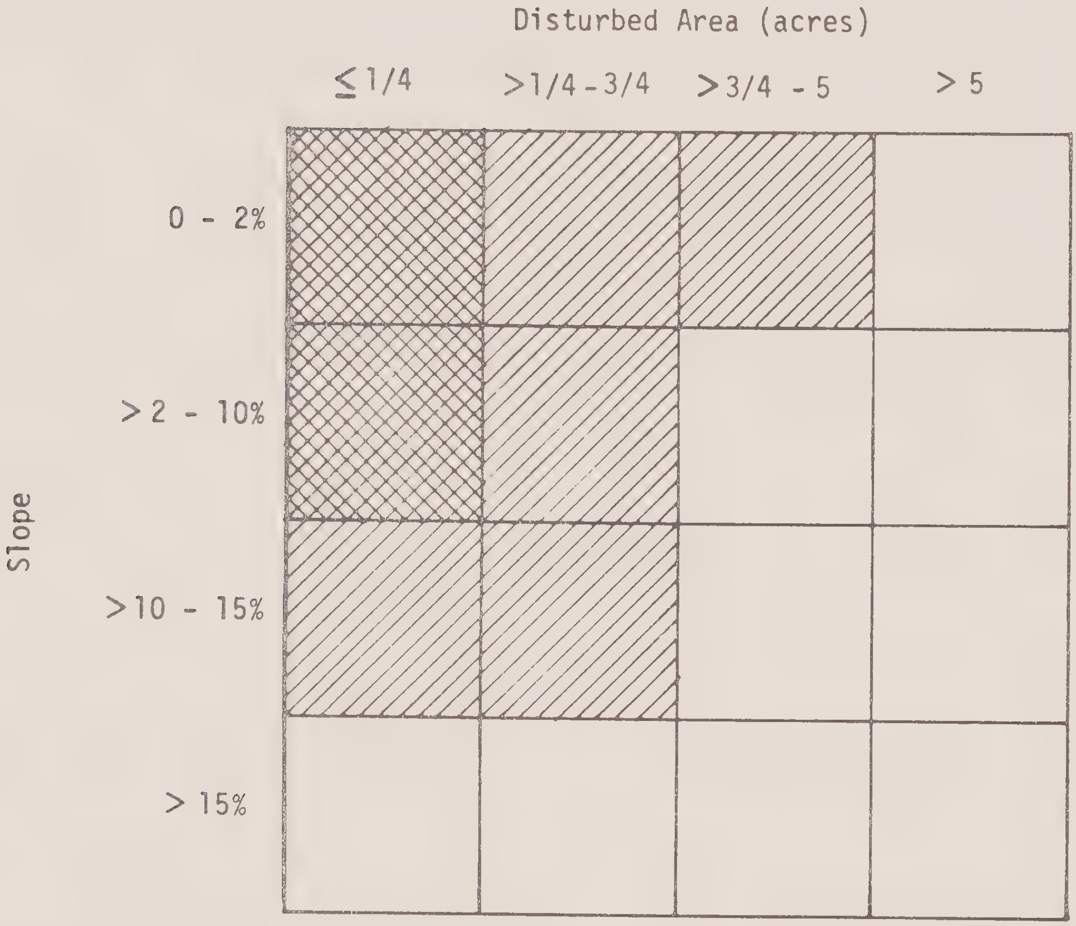
The model is based on analyses of published model ordinances and of existing ordinances in California and other states. It was reviewed by ABAG's Water Quality Technical Advisory Committee and the Citizens Advisory Committee, and revised pursuant to comments from committee members and other interested parties.

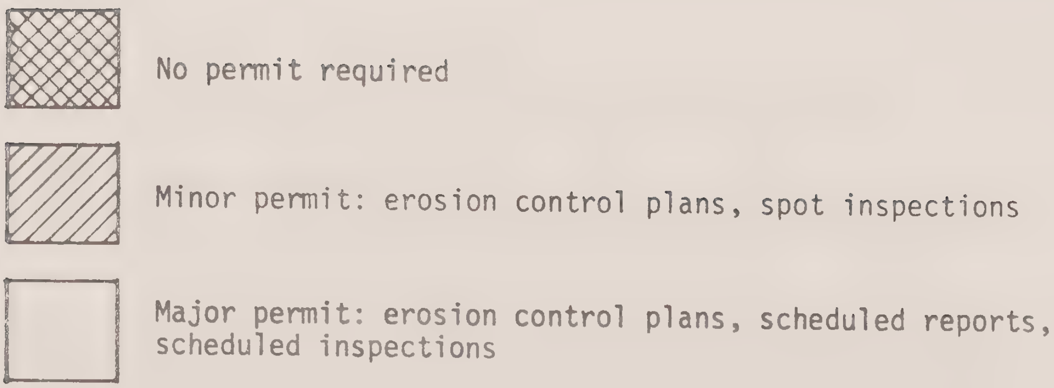
The model provides for three levels of regulation. Grading of small, relatively flat sites is exempted from the permit process. Grading of larger sites on flat to moderate slopes is controlled under the Minor permit process. Builders must submit erosion control plans but are not required to report. The site is subject to spot inspections. Grading of large sites or sites on steep slopes is controlled under the Major permit process. In addition to submitting erosion control plans, builders of these projects must report according to a schedule and the site is subject to scheduled inspections. Table I.A.2 summarizes this regulatory scheme.

TABLE I.A.1 OUTLINE OF MODEL EROSION AND SEDIMENT CONTROL ORDINANCE

	Ordinance Features	Section(s)
1.	Water quality is an explicit goal of the ordinance and a key criterion of the review process.	101.01., 301.01
2.	An erosion and sediment control plan is required prior to issuance of a grading permit.	201.02, 202.03, 202.04
3.	A manual of standards for surface runoff control measures on construction sites is maintained by the jurisdiction for use by developers and agency plan reviewers.	301.03, 301.04
4.	A schedule of reports, tied to the rainy season, is required of permittees.	402.01
5.	A schedule of inspections, tied to permittee reports and the rainy season, is required of the agency.	402.02(b)
6.	A variety of enforcement mechanisms, triggered by inspections, reports or other permittee or agency actions, is available to the local agency.	402.01, 403.02, 403.03

TABLE I.A.2 THRESHOLD LEVELS FOR MINOR AND MAJOR PERMITS IN MODEL EROSION CONTROL ORDINANCE





MODEL EROSION AND SEDIMENT CONTROL ORDINANCE

(To Amend an Existing Grading Ordinance)

Article I

Title, Purpose and General Provisions

101.00 Title. This ordinance shall be known as the "[City/County] Erosion and Sediment Control Ordinance" and may be so cited.

101.01 Purpose. The purpose of this Chapter is to promote and protect the public interest by regulating land disturbances, land fill and soil storage in connection with the clearing and grading of land for construction. The intent of this ordinance is to establish administrative procedures, minimum standards of review and implementation and enforcement procedures for the protection and enhancement of the water quality of watercourses, water bodies and wetlands, natural and man-made, by controlling erosion, sedimentation, increases in surface runoff and related environmental damage caused by construction-related activities.

101.02 Definitions. When used in this Chapter, the following words shall have the meanings ascribed to them in this Section:

(a) Administrator: the Director of [ ] and duly authorized agents and employees of [ ].

(b) Applicant: any person, corporation, partnership, association of any type, public agency or any other legal entity who submits an application to the Administrator for a permit pursuant to this Chapter.

(c) Best Management Practice (BMP): a technique or series of techniques which, when utilized in a designated manner, is proven to be effective in controlling construction-related runoff, erosion and sedimentation (see §101.02(i)).

(d) Erosion: the action or process of wearing away of earth or soil by the action of water.

(e) Final Erosion and Sediment Control Plan: a set of measures designed to control surface runoff and erosion and to retain sediment on a particular site after all other planned final structures and permanent improvements have been erected or installed.

(f) Interim Erosion and Sediment Control Plan: a set of measures designed to control surface runoff and erosion and to retain sediment on a particular site during the period in which pre-construction and construction-related land disturbances, fills and soil storage occur.

(g) Land disturbance/land disturbing activities: any human activity moving or removing the soil mantle or top 6 inches of soil whichever is shallower.

(h) Land fill: any human activity depositing soil or other earth materials.

(i) Manual of Standards (Manual): a compilation of technical application standards and design specifications adopted by the Administrator as being proven methods of controlling construction-related surface runoff, erosion and sedimentation (see §101.02(c)).

(j) Permittee: the applicant in whose name a valid permit is duly issued pursuant to this Chapter and his/her/its agents, employees and others acting under his/her/its direction.

(k) Sediment: material deposited by water.

(l) Site: a parcel or parcels of real property owned by one or more than one person which is being or is capable of being developed as a single project.

(m) Wet season: the period from [October 15 to April 15].

(n) Watercourse: [to be defined and designated by the local jurisdiction].

101.03 Severability and Validity. If any part of this ordinance is found not valid, the remainder of this ordinance shall remain in effect.

101.04 Nuisance Abatement. Neither this Chapter, nor any administrative ruling made under it, limits:

(a) The power of the [City/County] to declare, prohibit and abate a nuisance; or

(b) The right of any person to maintain, at any time, any appropriate action for relief against any private nuisance, or for relief against any contamination or pollution.

Article II

Permit Application Procedures

201.01 Scope. No person may grade, fill, excavate, store or dispose of soil and earthen materials or perform any other land-disturbing or land-filling activity without first obtaining a Permit as set forth in this Chapter.

201.02 Exemptions. All land-disturbing or land-filling activities or soil storage shall be undertaken in a manner designed to minimize surface runoff, erosion and sedimentation. A person performing such activities need not apply for a Permit pursuant to this Chapter in the following situations:

(a) Development or construction, on a single lot, of a single family residence when undertaken by the owner, and for which no prior permit pursuant to this Chapter has been issued, provided such activities also meet the requirements of Subsection (b) of this Section;

(b) Land disturbance or land fill of [1/4 acre or less on natural and finished slopes less than 10%]; or, where the volume of earth, soil or other earthern materials stored or disposed of is [50 cu. yds.] or less, or [50 tons] or less;

(c) Routine cemetary excavations and fills;

(d) Routine agricultural crop management practices;

(e) Emergencies posing an immediate danger to life or property, or substantial flood or fire hazards.

Except for Subsection (e) of this Section, the exemptions set forth in this Section shall not apply when the activity is undertaken in the following situations:

(1) on natural and finished slopes greater than 15%, or

(2) within 100 feet by horizontal measurement from the top of the bank of a watercourse, the mean high watermark (line of vegetation) of a body of water or within the wetlands associated with a watercourse or water body, whichever distance is greater.

202.00 Application. The application for a Permit must include all of the following items:

(a) Application form;

(b) Site Map and Grading Plan;

(c) Interim Erosion and Sediment Control Plan;

(d) Final Erosion and Sediment Control Plan, where required (see §301.07);

(e) Soils and Geological Reconnaissance Report, where required (see §301.05);

(f) Work schedule;

(g) Application fees;

(h) Performance bond or other acceptable security (see §202.07);

(i) Any supplementary material required by the Administrator.

202.01 Application Form. The following information is required on the application form:

(a) Name, address and telephone number of the Applicant;

(b) Names, addresses and telephone numbers of any and all contractors, subcontractors or persons actually doing the land-disturbing activity and their respective tasks;

(c) Name(s), address(es) and telephone number(s) of the person(s) responsible for the preparation of the Site Map and Grading Plan;

(d) Name(s), address(es) and telephone number(s) of the person(s) responsible for the preparation of the Interim and/or Final Erosion and Sediment Control Plan;

(e) Name, address and telephone number of the registered [Geologist] responsible for the preparation of the Soils and Geological Reconnaissance Report, where required (see §301.05);

(f) A vicinity map showing the location of the site in relationship to the surrounding area's watercourses, water bodies and other significant geographic features, and roads and other significant structures;

(g) Date of the application;

(h) Signature(s) of the owner(s) of the site or of an authorized representative.

202.02 Site Map and Grading Plan. The Site Map and Grading Plan shall contain all the following information:

(a) Existing and proposed topography of the site taken at not more than a [x-foot] contour interval over the entire site. Ninety percent (90%) of the contours shall be plotted within one contour interval of the true location;

(b) Two contour intervals that extend a minimum of [100 feet off-site, or sufficient to show on- and off-site drainage];

(c) Site's property lines shown in true location with respect to the plan's topographic information;

(d) Location and graphic representation of all existing and proposed natural and man-made drainage facilities;

(e) Location and graphic representation of proposed excavations and fills, of on-site storage of soil and other earthen material, and of on-site disposal;

(f) Location of existing vegetation types and the location and type of vegetation to be left undisturbed;

(g) Location of surface runoff, erosion and sediment control measures as required under §202.03(d);

(h) Quantity of soil or earthen materials in tons and cubic yards to be excavated, filled, stored or otherwise utilized on-site;

(i) Outline of the methods to be used in clearing vegetation, and in storing and disposing of the cleared vegetative matter;

(j) Proposed sequence and schedule of excavation, filling and other land-disturbing and filling activities, and soil or earthen material storage and disposal.

202.03 Interim Erosion and Sediment Control Plan (Interim Plan). All the following information shall be provided with respect to conditions existing on the site during land-disturbing or filling activities or soil storage:

(a) Maximum surface runoff from the site shall be calculated using the method approved by the Administrator and maintained in the Manual, or any other method proven to the Administrator to be as or more accurate;

(b) Sediment yield shall be calculated using the method approved by the Administrator and maintained in the Manual, or any other method proven to the Administrator to be as or more accurate;

(c) The Interim Plan shall also contain the following information:

(1) a delineation and brief description of the measures to be undertaken to retain sediment on the site, including, but not limited to, the designs and specifications for berms and sediment detention basins, and a schedule for their maintenance and upkeep,

(2) a delineation and brief description of the surface runoff and erosion control measures to be implemented, including, but not limited to, types and method of applying mulches, and designs and specifications for diverters, dikes and drains, and a schedule for their maintenance and upkeep,

(3) a delineation and brief description of the vegetative measures to be taken, including, but not limited to, seeding methods, the type, location and extent of pre-existing and undisturbed vegetation types, and a schedule for maintenance and upkeep;

(d) The location of all the measures listed by the Applicant under Subsection (c) above, shall be depicted on the Site Map and Grading Plan (see §202.02 (f)-(g));

(e) An estimate of the cost of implementing and maintaining all interim erosion and sediment control measures must be submitted in a form acceptable to the Administrator.

202.04 <u>Final Erosion and Sediment Control Plan (Final Plan)</u>. All the following information shall be provided with respect to conditions existing on the site after final structures and improvements (except those required under this Section) have been completed and where these final structures have not been covered by an Interim Plan, (see §301.07):

(a) Maximum runoff from the site shall be calculated using the method approved by the Administrator and maintained in the Manual, or any other method proven to the Administrator to be as or more accurate;

(b) Sediment yield shall be calculated using the method approved by the Administrator and maintained in the Manual, or any other method proven to the Administrator to be as or more accurate;

(c) The Final Plan shall also contain the following information:

(1) a description of and specifications for sediment retention devices,

(2) a description of and specifications for surface runoff and erosion control devices,

(3) a description of vegetative measures,

(4) a graphic representation of the location of all items in Subsections (1)-(3) above;

(d) An estimate of the costs of implementing all final erosion and sediment control measures must be submitted in a form acceptable to the Administrator.

202.05 <u>Soils and Geological Reconnaissance Report (Soils Report)</u>. A Soils Report, when required by the Administrator (see §301.05), shall be based on adequate test borings, as necessary, and shall contain all the following information:

(a) Data regarding the nature, distribution and erodibility of existing soils;

(b) Data regarding the nature, distribution and erodibility of soil to be placed on the site, if any;

(c) Conclusions and recommendations for grading procedures;

(d) Conclusions and recommended designs for interim soil stabilization devices and measures and for permanent soil stabilization after construction is completed.

202.06 Work Schedule. The Applicant must submit a master work schedule showing the following information:

(a) Proposed grading schedule;

(b) Proposed conditions of the site on each [July 15, August 15, September 15, October 1 and October 15] during which the Permit is in effect;

(c) Proposed schedule for installation of all interim erosion and sediment control measures including, but not limited to, the stage of completion of erosion and sediment control devices and vegetative measures on each of the dates set forth in Subsection (b);

(d) Schedule for construction, if any;

(e) Schedule for installation of permanent erosion and sediment control devices where required (see §301.07).

202.07 Security

(a) The Applicant shall provide security for the performance of the work described and delineated on the approved Grading Plan in an amount to be set by the Administrator [but not to exceed 100%] of the approved estimated cost of the grading. The form of security shall be one or a combination of the following to be determined by the Administrator:

(1) bond or bonds issued by one or more duly authorized corporate sureties. The form of the bond or bonds shall be subject to the approval of the [City Attorney/County Counsel],

(2) deposit, either with the city or a responsible escrow agent or trust company at the option of the [City/County], of money, negotiable bonds of the kind approved for securing deposits of public monies, or other instrument of credit from one or more financial institutions subject to regulation by the State or Federal government wherein said financial institution pledges funds are on deposit and guaranteed for payment.

(b) The Applicant shall provide security for the performance of the work described and delineated in the Interim Plan in an amount to be determined by the Administrator but not less than 100% of the approved estimated cost of performing said work. The form of the security shall be as set forth in Subsections (a)(1) and (2).

(c) The Applicant shall provide security for the performance of the work described and delineated in the Final Plan in an amount to be determined by the Administrator but not less than 100% of the approved estimated cost of performing said work. The form of the security shall be as set forth in Subsections (a)(1) and (2).

203.01 Fees. The following fees are to be paid pursuant to a schedule of fees adopted, and amended from time to time by the [City Council/Board of Supervisors] upon recommendation by the Administrator:

(a) A permit processing fee, to be paid at the time the permit application is submitted;

(b) An inspection fee to be paid at the completion of the work described in the Interim Plan;

(c) An inspection fee to be paid at the completion of the work described in the Final Plan;

(d) The Administrator may at his option require partial payment of the fees set forth in Subsections (b) and (c) of this Section before issuing a permit.

204.01 Decision on a Permit. The Administrator shall review all documents submitted pursuant to this Chapter and, if necessary, request additional data, clarification of submitted data or correction of defective submissions within 10 working days after the date of submission. The Administrator shall notify Applicant of his decision on the permit within 20 working days of the initial submission or of the corrected submissions, whichever is later.

204.02 Permit Issuance. Approval of an application by the Administrator shall be issued, if at all, within [3] working days.

204.03 Permit Duration. Permits issued under this Chapter shall be valid for the period during which the proposed land-disturbing or filling activities and soil storage takes place or is scheduled to take place, whichever is shorter. Permittee shall commence permitted activities within 60 days of the scheduled commencement date for grading or the Permitee shall resubmit all required application forms, maps, Plans, schedules and security to the Administrator. The Administrator may require additional fees.

204.04 Permit Denial. The Applicant may request a hearing before the [City Council/Board of Supervisors] within [5] working days of notification of a permit denial. The hearing shall be held within [15] working days.

204.05 Assignment of Permit. A Permit issued pursuant to this Chapter may be assigned, provided:

(a) The Permittee notifies the Administrator of the proposed assignment;

(b) The proposed assignee:

(1) submits an application form pursuant to §202.01, and

(2) agrees in writing to all the conditions and duties imposed by the Permit, and

(3) agrees in writing to assume responsibility for all work performed prior to the assignment, and

(4) provides security pursuant to §202.07, and

(5) agrees to pay all applicable fees pursuant to §202.08;

(c) The Administrator approves the assignment.

The Administrator shall set forth in writing the reasons for his/her approval or disapproval of an assignment.

Article III

Review Standards and Procedures

301.01 Review Policy. The Administrator shall issue a Permit provided he/she finds that the plans submitted in application for a Permit individually and in the aggregate:

(a) Protect the quality of receiving waters;

(b) Minimize surface runoff, erosion and off-site sedimentation:

(1) to the extent feasible, or

(2) in the case where the work site is situated in a §201.02(1)-(2) area, to the extent possible.

301.02 Site Map and Grading Plan. Before approving the Site Map and Grading Plan, the Administrator shall find as required by §301.01.

(a) The review process shall include, but is not limited to, examination of the Site Map and Grading Plan for:

(1) adherence to the requirements set forth in §202.02,

(2) signature(s) by a [Civil Engineer, or other qualified persons],

(3) internal coherence.

(b) Where the Site Map and Grading Plan cannot be approved as submitted, the Administrator may require the Applicant to adopt one or all of the following measures:

(1) reduce the area of land to be disturbed,

(2) restrict land-disturbing or filling activities or soil storage to the dry season (see also §402.01(c)),

(3) revise and resubmit Site Map and Grading Plan.

(c) The Site Map and Grading Plan, if approved, either as submitted or as modified under Subsection (b), is part of the Permit.

301.03 Interim Plan. Before approving the Interim Plan, the Administrator shall find as required by §301.01.

(a) The Applicant may propose the use of any erosion and sediment control techniques in the Interim Plan provided such techniques are proven to be as or more effective than the equivalent BMP contained in the Manual.

(b) The review process shall include, but is not limited to, examination of each proposed technique, individually or in the aggregate, for:

(1) suitability to and effectiveness under the anticipated conditions at the work site both at the onset of and throughout the wet season,

(2) location(s) on the work site,

(3) size(s), carrying or holding capacity(ies) and design(s) for controlling the predicted surface runoff and sediment yield,

(4) allotted time(s) for full installation and implementation,

(5) sequencing, both among themselves and in concert with land-disturbing activities, especially when land-disturbing and filling activities and soil storage will commence either at the onset of or during the wet season,

(6) proposed maintenance method(s) and schedule(s).

(c) The Administrator shall require the Applicant to change the proposed technique or BMP, or any facet thereof, where he/she deems necessary.

(d) The Interim Plan, as approved or as modified under §402.02(a), is a part of the Permit.

301.04 Final Plan. Before approving the Final Plan, the Administrator shall find as required under §301.01.

(a) The Applicant may propose the use of any erosion and sediment control techniques in the Final Plan provided such techniques are proven to be as or more effective than the equivalent BMP contained in the Manual.

(b) The review process shall include, but is not limited to, examination of each proposed technique, individually and in the aggregate, for:

(1) suitability to and effectiveness under the anticipated conditions at the work site throughout the period during which the Final Plan is to be implemented and in effect,

(2) location(s) on the work site,

(3) adequacy of the proposed size(s), carrying and holding capacity(ies) and design(s) for controlling the predicted surface runoff and sediment yield,

(4) allotted time(s) for full installation and implementation,

(5) proposed maintenance method(s) and schedule(s).

(c) The Administrator shall require the Applicant to change the proposed technique or BMP, or any facet thereof, where he/she deems necessary.

(d) The Final Plan, as approved or as modified under §402.02(a), is a part of the Permit.

301.05 Soils Report. A Soils Report meeting the criteria set forth in §202.05 shall be required for all Major Permits. A Soils Report shall also be required for a Minor Permit unless the Administrator determines that all of the following apply:

(a) The soil type for the region in which the work site is situated is recorded in the Manual, an official survey by local state or federal agencies or other widely recognized authority in the field of [ ];

(b) The soil type, as recorded, is sufficiently precise to be utilized in the equations, referenced in §§202.03(b) and 202.04(b);

(c) The soil on the work site is representative of the region surveyed by the literature of Subsection (a);

(d) The site is not in a §201.02(1)-(2) area.

301.06 Work Schedule. The Administator shall review the work schedule for overall coherence. Any modifications to the Site Map and Grading Plan, Interim Plan and Final Plan shall be noted on the work schedule and the schedule modified, as necessary.

301.07 Coordination with Other Permits. Where a person applies to the Administrator for a Permit pursuant to this Chapter and either does not apply for the necessary permits to make improvements on the same site or applies for the permits necessary to make only a portion of the prospective improvements on the same site, the Applicant need not submit a Final Plan for the site or those portions of the site wherein Applicant does not plan to make improvements, and this Section shall apply.

(a) The Interim Plan shall be adequate to control surface runoff and sedimentation from the unimproved areas of the site for the period of time between termination of the Permit and implementation of a Final Plan, pursuant to Subsection (c) of this Section.

(b) The security for the Interim Plan shall be retained until a Final Plan(s) has been implemented. The security may be released on a pro rata basis where a Final Plan or series of Final Plans is/are implemented for a portion or portions of the site.

(c) No [building permit, permit of occupancy, etc.] shall be issued until the Applicant for such a permit has presented to the permitting agency certification from the Administrator that:

(1) a Final Plan has been filed with and approved by the Administrator pursuant to this Chapter,

(2) security for the Final Plan has been posted in accordance with §202.07(c),

(3) Applicant presenting such certification has agreed in writing to implement the Final Plan pursuant to the requirements and enforcement procedures of this Chapter,

(4) Applicant has paid all pertinent fees.

Article IV

Implementation and Enforcement

401.01 Minor Permit.

(a) The Administrator shall issue a Minor Permit only if:

(1) total area of disturbed or filled land is [1/4] acre or less, and the natural and finished slopes are greater than 10%, and 15%, or less, or

(2) total area of disturbed or filled land is [3/4] acre or less and greater than [1/4], and the natural and finished slopes are 15%, or less, or

(3) total area of disturbed or filled land is greater than [3/4] acre but less than [5] acres, and the natural and finished slopes are 2%, or less,

Provided, in all of the situations defined in (a)(1)-(3), above:

(4) total volume of stored soil is [1,200 cubic yards] or less, and

(5) none of the activity is in a §201.02(1)-(2) area.

(b) The Minor Permit is issued subject only to the conditions set forth in §401.03.

(c) The Administrator shall enforce a Minor Permit only through the procedures set forth in §403.01, or by inspections at the discretion of the Administrator, or by any other means available at law or in equity.

401.02 Major Permit.

(a) All permits other than Minor Permits issued under this Chapter are Major Permits.

(b) The Major Permit is issued subject to the conditions set forth in §§401.03 and 402.01-02.

(c) The Administrator shall enforce a Major Permit through any procedures set forth in this Article or by any other means available at law or in equity.

401.03 <u>Issuance of Major and Minor Permits</u>. Administrator shall issue a Major or Minor Permit upon approval of a Site Map and Grading Plan, Interim Plan, Final Plan, where required (see §301.07), Soil Report, where required (see §301.05), deposit of appropriate security and payment of fees. The Major and Minor Permits shall be issued subject to the following conditions:

(a) The Permittee shall maintain a copy of the Permit, approved plans and, for Major Permits only, reports required under §402.01, on the work site and available for public inspection during all working hours;

(b) The Permittee shall, at all times, be in conformity with approved Site Map and Grading Plan, Interim and Final Plans.

402.01 <u>Implementation of Major Permits--Permittee's Duties</u>. In addition to performing as required under §401.03, Permittee shall:

(a) Notify the Administrator, at least forty-eight (48) hours beforehand, of the beginning of land-disturbing or filling activities or soil storage;

(b) Submit to the Administrator, reports on:

(1) the progress of or delays in land-disturbing or filling activities or soil storage,

(2) any other departures from the approved Site Map and Grading Plan which may affect implementation of the Interim or Final Plans as scheduled,

(3) possible delays in obtaining materials, machinery, services or manpower necessary to the implementation of the Interim or Final Plans as scheduled,

(4) the progress of or delays in the implementation of the Interim or Final Plans,

(5) any other departures from implementation of the Interim or Final Plans,

(6) according to the schedule set forth below:

(i) for the period from [April 15] to July 31, monthly;

(ii) for the period from August 1 to September 30, weekly;

(iii) for the period from October 1 to October 15, twice a week;

(iv) for the period from [October 16 to April 14], weekly;

(c) When Permittee proposes to commence land-disturbing or filling activities or soil storage during the wet season, Permittee shall demonstrate that land disturbance is relatively minor and that erosion can be easily controlled, or is a necessary and integral part of an Interim Plan for previously-initiated project phases. Where such activities are approved, Permittee shall submit:

(1) a report seventy-two (72) hours prior to and, again, at the start of land-disturbing or filling activities or soil storage,

(2) a report seventy-two (72) hours prior to and, again, at the start of implementing the Interim Plan,

(3) a report upon completion of the Interim Plan,

(4) any other reports required under subsection (b) of this Section.

Each report shall contain, where pertinent, the elements described in Subsections (b)(1)-(5) of this Section;

(d) Submit to the Administrator, upon termination of the Permit:

(1) a report on and graphic representation of the Final Plan, as implemented, and

(2) a copy of the instructions to be given to the new owners of the improved property by the Permittee or his/her agent regarding the maintenance of the surface runoff, erosion and sediment control measures and devices implemented under the Final Plan,

or,

(3) for those areas where no Final Plan is required, a report and graphic representation of the Interim Plan, as implemented, and

(4) contracts for the maintenance and upkeep of the surface runoff, erosion and sediment control measures and devices implemented under the Interim Plan, for the period during which the site will remain unimproved;

(e) Have an authorized representative of each contractor or subcontractor actually performing the land-disturbing or filling activities or soil storage, or actually procuring the materials, machinery, services or manpower for the implementation of Interim or Final Plans, sign each report pertinent to him or her, and certify the contents thereof as true. The Permittee shall sign all reports submitted to the Administrator and shall attest that each is true and accurate to the best of his or her knowledge.

402.02 Implementation of Major Permits--Administrator's Duties.

(a) The Administrator shall review all reports submitted by Permittee. Where the Administrator finds:

(1) delays in implementing or departures from the approved Site Map and Grading Plan, Interim or Final Plans,

(2) problems with or breakdowns in any technique provided for by the Interim or Final Plan which are attributable to:

(i) the Plans themselves,

(ii) their maintenance methods or schedules,

(iii) any other causes,

which may have a deleterious effect on the quality of receiving waters, or increase surface runoff, erosion or off-site sedimentation, the Administrator shall require the Site Map and Grading Plan, Interim or Final Plans, and maintenance methods and schedules be modified so as to achieve the same level of water quality and surface runoff, erosion and sediment control as would have been achieved had these problems not arisen. The Administrator shall notify the Permittee in writing of the requirement. Permittee shall comply with the order to modify within [x] working days.

(b) The Administrator shall inspect the work site for compliance with conditions set forth in §401.03, for verification of reports submitted under §402.01, and for the quality of the work being performed under the Interim or Final Plan. Said inspections shall take place:

(1) [within five (5) working days of July 15],

(2) [within five (5) working days of September 1],

(3) [within five (5) working days of September 15],

(4) [weekly from October 1 through 15],

(5) [within three (3) working days of] or during, the first major rainfall of the wet season,

(6) under circumstances described in §402.01(c),

(i) at the onset of implementation of the Interim Plan, and

(ii) at the onset of land-disturbing or filling activities or soil storage,

(7) after notification to the Permittee of an order to modify under Subsection(a) of this Section,

(8) at any other time, at the Administrator's discretion.

(c) The inspector shall file a written memorandum on:

(1) the conditions of the work site,

(2) whether Permittee is in compliance with approved plans,

(3) whether Permittee is in conformity with filed reports,

(4) whether Permittee is in comformity with the Interim or Final Plan,

(5) whether Permittee is effectively controlling surface runoff, erosion and off-site sedimentation.

403.01 Suspension or Revocation of Permit. The Administrator shall first have resort to the procedures set forth in this Section before any other enforcement procedure set forth in this Article.

(a) The Administrator shall suspend the Permit and issue a stop work order, and Permittee shall cease all work on the work site, except work necessary to remedy the cause of the suspension, upon notification of such suspension when:

(1) Permittee fails to submit reports timely and in accordance with §402.01,

(2) inspection by the Administrator under §402.02(b)(1)-(8) reveals that the work or the work site:

(i) is not in compliance with the conditions set forth in §401.03, or

(ii) is not in conformity with the Site Map and Grading Plan, Interim or Final Plan as approved or as modified under §402.02(a), or

(iii) is at variance with reports submitted under §402.01(a)-(e), or

(iv) is not in compliance with an order to modify under §402.02(a),

(3) Permittee fails to comply with an order to modify within the time limits imposed by the Administrator (see §402.02(a)).

(b) The Administrator shall revoke the Permit and issue a stop work order, and Permittee shall cease work upon the occurrence of any of the following conditions:

(1) Permittee fails or refuses to cease work, as required under (a) above, after suspension of the Permit and receipt of a stop work order and notification thereof,

(2) any of the conditions set forth in Subsection (a) of this Section occurs in a §201.02(1)-(2) area.

(c) The Administrator shall reinstate a suspended Permit upon Permittee's correction of the cause of the suspension.

(d) The Administrator shall not reinstate a revoked Permit.

403.02 Fines and Penalties. It shall be a misdemeanor for any person to perform work in violation of a stop work order issued pursuant to §403.01(a)-(b). The [City/County] may impose a fine of $500 and/or a prison term of thirty (30) days for each day that:

(a) Permittee continues working in violation of a stop work order;

(b) Permittee is not in compliance with the Interim Plan or Final Plan at the onset of the wet season.

403.03 Action against/Release of the Security. The Administrator may request the [City Attorney/District Attorney] to commence an action against the pertinent security if:

(a) The Permittee ceases land-disturbing activities and abandons the work site prior to completion of the Site Map and Grading Plan;

(b) The Permittee fails to conform to the Interim Plan as approved or as modified under §402.02(a);

(c) The Permittee fails to comply with the Final Plan or an Interim Plan as approved or modified under §402.02(a); or the techniques utilized under either Plan fail within one (1) year of installation, or a Final Plan is implemented for the site or portions of the site, whichever is later;

The monies obtained from a successful action against the Security shall be used to finance remedial work undertaken by the [City/County] or a private contractor under contract to the [City/County], and to reimburse the [City/County] for the cost of litigation;

(e) Securities held against the successful completion of the Site Map and Grading Plan and the Interim Plan, except for Interim Plans described in §301.07, shall be released to the Permittee at the termination of the Permit, provided no action against such security is filed prior to that date;

(f) Securities held against the successful completion of the Final Plan and an Interim Plan described in §301.07 shall be released to the Permittee either one (1) year after termination of the Permit or when a Final Plan is submitted for the unimproved site, whichever is later, provided no action against such security has been filed prior to that date.

403.04 Cumulative Enforcement Procedures. The procedures for enforcement of a Permit, as set forth in this Article, are cumulative and not exclusive.

WQ/Tech Memo/March 1980
E. Chan/A. Smith

WATER QUALITY MANAGEMENT PLAN

ASSESSMENT OF CONSTRUCTION INSPECTION AND INSPECTOR TRAINING PROGRAMS FOR EROSION CONTROL

Technical Memorandum No. 48
March 12, 1980

I. INTRODUCTION

Problem Statement

Erosion and sedimentation were identified as major surface runoff problems in all of the County Surface Runoff Management Plans prepared for the Environmental Management Plan. Erosion of streambanks and sedimentation into watercourses can have long-reaching environmental effects such as water quality degradation, loss of aquatic habitat, reduction in biological productivity and reduction in stream capacity leading to flooding.

Construction is a major contributor to these problems in the Bay Area. As discussed in Technical Memo No. 11*, soil loss rates typically increase over 200 times after ground disturbance, and in construction areas, can increase 2000 times above pre-construction conditions.

Each year, thousands of projects affecting many acres are approved by local governments. For each of these projects, a wide variety of Best Management Practices can be applied during construction to minimize erosion problems. The opportunity for each community to incorporate and regulate these practices arises during the project review and approval process where they can be required in building and grading permits and enforced during routine construction inspections.

Objectives

Construction site inspection should be an integral part of local and countywide efforts to control soil erosion and sedimentation in drainage courses. The frequency and thoroughness of construction or grading inspections has a direct bearing on the minimization of erosion and the success of specific measures to control erosion.

*Surface Runoff Technical Memo No. 11- "The Project Review Process and It's potential to Control Erosion," April 1979.

The objectives of this technical memorandum are:

- to survey existing construction inspection conditions;
- to examine the duties and qualifications of construction inspectors;
- to survey existing types of inspector training and certification;
- assess the role of inspection in surface runoff management;
- review the implications of grading ordinances requiring erosion control plans and inspections;
- review existing erosion control training;
- develop a proposed Bay Area erosion control training and information program; and
- to assess the fiscal implications of these programs.

Construction Inspection and Inspector Training Programs in the Context of Water Quality Management

The goal of construction site inspection for erosion control should be to minimize the environmental damage that can be caused by specific projects. Removal of ground cover and disturbance of surface layers can lead to accelerated loss of topsoil, washdown of sediments and pollutants into drainage courses, contamination of surface waters and degradation of riparian and aquatic systems. Even with the most well-intentioned ordinances and comprehensively-designed erosion control plans, without effective implementation - as documented by site inspections - environmental damage can occur.

This memorandum, after review by the Water Quality Technical Advisory Committee, will become part of the water quality portion of the Environmental Management Plan and will provide information to cities and counties enabling them to improve the erosion control capabilities of their inspection staff.

II. CONCLUSIONS AND RECOMMENDATIONS

Several conclusions of this memorandum include:

1. Inspection for erosion and sedimentation problems (other than that required in a grading permit) generally is not required in the majority of Bay Area construction projects. Building inspectors (structural, etc.) are usually not trained in erosion control methods.

2. Ineffective ordinances, understaffing, lack of training for erosion control inspection, and poor or infrequent enforcement all contribute to the problem of ineffective erosion control.

3. Local academic programs in construction inspection give limited or no training in erosion control. A Bay Area training program would provide valuable instruction to local inspectors.

Based on an assessment of existing construction inspection conditions and future needs to be developed with the improvement of grading ordinances and use of erosion control plans, the following recommendations are made:

1. Cities and counties should require all grading and public works inspectors to have sufficient training to recognize erosion and sediment problems, recommend control measures, interpret erosion control plans and perform adequate inspections for compliance.

2. The requisite training can be obtained by attending an erosion control training program of the type outlined in this technical memorandum and obtaining a certificate of satisfactory course completion.

3. A Bay Area erosion control training program for developers and construction inspectors should be developed by ABAG as part of the 208 Water Quality Management Program. Participation by cities and counties should be encouraged.

4. Training program recognition and certification through local educational institutions (such as community colleges) or professional societies should be explored. If feasible, joint sponsorship and development with local agencies or groups should be encouraged.

5. The training program should be developed to respond to local problem conditions and became a permanent program that can be offered through an educational institution or local agency.

6. Public information programs should include information and awarness programs as well as pamphlets and resource material targeted at developers, landscape professionals and homeowners who may be dealing with soil stabilization through structural or vegetative methods.

III. SURVEY OF CONSTRUCTION INSPECTION AND TRAINING

A short survey was sent to departments in several counties involved in building and site inspection requesting information on construction inspector qualifications, duties and existing inspector training programs. The survey form is attached in Appendix A. The counties surveyed included: Marin, San Mateo, Santa Clara, Alameda and Solano Counties. Additional interviews were conducted to determine where inspection for erosion control fit into the routine inspection process, and to what extent erosion control inspection occurred. A second survey was conducted on local educational institutions for programs on construction inspection and related areas.

The results of these surveys and interviews are presented below under: "Existing Inspection for Erosion Control", "Inspector Qualifications" "Training of Existing Inspectors" and "Local Educational Programs."

Existing Inspection for Erosion Control

Many cities and counties have two departments which are involved in construction inspection for structual and non-structual or exterior work. Building or sometimes Planning Departments deal with the structure itself--electrical and plumbing inspections are done by those departments. Non-structual components including grading, drainage, septic systems and access, are inspected by Public Works or Land Development sections of the jurisdiction. Public Works and Planning Department inspectors duties include non-structural or structural inspection, as well as plan review. These departments are responsible for inspection of the many components of building and engineering projects. For example, the Alameda County Public Works Department combines grading and road construction inspection into one section of their office.

Most jurisdictions in the Bay Area inspect for erosion control when it is directly related to grading permits for specific projects. As reviewed in Technical Memo No. 34- "Grading Ordinances and Surface Runoff Control," grading permits are required only when cutting or filling exceeds quantities specified by the local ordinance. For example, Oakland requires a grading permit when more than 50 cu.yd. will be removed; whereas the threshold is 150, 200, 300 and 500 cu. yd. for Santa Clara County, Contra Costa County, the City of Hayward and Solano County respectively. The permits are usually activity-specific (i.e., a retaining wall) and inspections are primarily conducted for compliance with design specifications. Extensive land clearing and disturbance are typically not covered by grading ordinances. Where erosion and sedimentation problems occur from activities other than that covered under a grading permit, the inspector may refer the developer to the local Soil Conservation Service Office, make general comments, or make no comment at all.

Inspector Qualifications

Construction inspectors should have a thorough knowledge of construction materials and practices, usually developed in years of work as a craft worker or supervisor. They must also have current knowledge of codes, ordinances and regulations involved in construction. Other considerations are good physical condition in order to climb about on construction sites, possession of a vehicle operator's license and the ability to pass a civil service examination for some jurisdictions.

Inspector education levels range from a high school graduation with experience through college education with advanced degrees in related fields. A two-year college degree, such as the A.A. degree in Construction Inspection offered at Chabot College, is desireable to many employers. Most importantly, the inspector is expected to have direct experience in the construction trades. Licensing of construction inspectors is regulated by the Board of Registered Construction Inspectors under the California Department of Consumer Affairs. With recent amendments to the Registered Construction Inspectors Law, as of 1 January 1980, construction inspection must be performed by licensed inspectors registered through the Construction Inspectors Board. Categories for registration include the following divisions:

- Engineering
- Building
- Public Works
- Specialties (e.g., Earthworks, Combination-building and 12 other specialities)

Of these divisions, the law qualifies engineering, public works and earthworks-speciality inspectors to inspect erosion control-related facilities. Qualifications for construction inspector registration include a high school or equivalent education, four-to-seven years of professional experience and a passing score on a construction inspector examination administered by the Board. Professional experience for example, can consist of 4 years as a journeyman-of which 2 years were as a foreman-and 2 years of inspection experience. Academic training such as a college program in construction inspection may be substituted for experience. The aim of the Construction Inspectors Law is to establish standardized qualifications for inspectors to ensure the adequacy of construction inspection.

Training of Existing Inspectors

All inspectors have had some experience in the field before being hired and are given "on-the-job" training within the specific area--external or internal--that they inspect. On-the-job training can include an apprenticeship period with a regular inspector and where available--handbooks, slide programs and manuals. For all the

jurisdictions surveyed, there were no formal training programs. The only type of training for erosion control in some agencies involved exposure to building inspection manuals which contained one or two chapters on erosion problems. In general, inspectors receive very little additional training with respect to erosion control.

Local Educational Programs

Construction technology and related programs are offered at eleven community colleges in the Bay Area as presented in Table 1. Construction technology programs typically provide a well-rounded background in construction techniques, materials and technical aspects of construction. With advanced courses in inspection, a craft-worker could advance into the inspection field.

Three colleges - Chabot, Diablo Valley College and College of San Mateo offer degree or certificate programs in construction inspection. Santa Rosa Junior College also offers advanced courses in inspection. A two-year construction inspection program, such as that offered at Chabot College includes: surveying, technical mathematics, blueprint reading and sketching, report writing, building codes, plan review processes, elements of supervision, soils laboratory and concrete laboratory.

San Jose State University offers a graduate program in Public Works Inspection through the School of Traffic Engineering. The University of California Extension also offers a short course on "Field Supervision of Public Works Projects."

Of the A.A. and Certificate Programs surveyed, few had instruction available in erosion control and only to a limited extent. This type of material was usually covered in a regular civil or construction engineering program. While instruction in soil mechanics was available in some A.A./Certificate Programs it was specifically related to foundations, retaining walls and septic systems.

Conclusions on Existing Conditions

Based on the surveys and interviews discussed above, the following conclusions are drawn:

- Projects are generally not inspected for erosion or sedimentation problems unless it is directly related to a grading permit for a specific activity.

- The education and training background for inspectors varies widely. Experience in the construction trade is essential and licensing by the State Registered Construction Inspectors Board is now required.

- Limited or no on-the-job training is available for inspectors on erosion control.

TABLE I
LOCAL EDUCATIONAL PROGRAMS ON CONSTRUCTION

College and Location	Name of Program	Instruction available in Inspection	Instruction available in Erosion Control	Certificate(s) or Degree(s) Awarded
Diablo Valley College, Pleasant Hill	Construction Inspection	Yes	Limited	Certificate
Contra Costa College, San Pablo	Construction Technology	No	No	None
Laney College, Oakland	Construction Technology	No	No	A. A.
Chabot College, Hayward	Construction Inspection	Yes	Limited	A. A.
Ohlone College, Fremont	Construction Supervison	No	No	A. A.
San Jose City College, San Jose	Construction Technology	No	No	Certificate
West Valley College, Saratoga	Construction Technology	Yes	Limited	A.A., A.S.
Gavilan College, Gilroy	Construction Technology	No	No	Certificate, A.A.
College of San Mateo, San Mateo	Building Inspection	Yes	No	Certificate
San Francisco City, College, S.F.	Construction Management	No	No	A.S.
Santa Rosa Junior College, S.R.	Construction Technology	Yes	Limited	Certificate
San Jose State University	Public Works Inspection	Yes	Yes	M.S.
University of Calif. Extension, Berkeley	Field Supervision of Public Works Projects	Yes	No	None

- Local educational programs can provide a good background in construction inspection. Instruction in erosion control is limited and could provide a valuable supplement to these programs.

IV. ASSESSING THE ROLE OF CONSTRUCTION INSPECTION

At the present time, inspection of construction sites for erosion control appears to be the exception rather than the rule. This can be attributed to:

- ineffective grading ordinances that do not require systematic plan review and erosion control inspections;
- poor or infrequent enforcement of ordinances by local jurisdictions;
- lack of defined erosion control inspection duties for construction inspectors;
- inadequate staffing at Building Inspection Departments due to budget restrictions or shortage of plan reviewers and trained inspectors; and
- plan reviewers, site inspectors and builders often have limited or no training in erosion problems and their control.

The problem, then, is how to make sure that construction sites are inspected for erosion control problems and appropriate preventive and follow-up measures are taken. Solving this problem involves development of more comprehensive grading ordinances, provision for site-specific erosion control plans, increased staffing and training for plan reviewers and inspectors and training for builders and related professions as well.

Improving Grading Ordinances

ABAG recently surveyed grading ordinances within 92 jurisdictions of the region. Features were compared, areas for improvement were noted and a compilation of features for an effective grading ordinance were presented in Technical Memo No. 34 - "Grading Ordinances and Surface Runoff Control." Some of the problems noted were that most of the ordinances gave local officials unguided discretion in determining the standards necessary for compliance, and that plan checking and site inspection were inconsistently performed.

Features of an effective grading ordinance that relate directly to construction site inspection are:

- The ordinance provides for a specialized staff trained in the control of erosion, sedimentation and/or stormwater runoff.
- The number and timing of on-site inspections is specified in the ordinance.
- Inspection results are reported directly in writing to the permittee.
- A copy of the grading and erosion control plan is maintained on the work site and is available to the inspector at all times.
- The permittee notifies the administering agency 48 hours before any land disturbance is undertaken and after the final grading and land stabilization is performed.
- The permittee secures approval from the administering agency before removing any erosion, sedimentation or stormwater control structure.
- The permittee files a certificate of project completion with the administering agency, which then conducts the final inspection and prepares a written final report for its files, with a copy to the permittee.

Erosion Control Plans

One of the main features for an effective grading ordinance presented in Tech. Memo No. 34 was the requirement of a grading and erosion control plan prior to issuance of a grading permit.

A grading plan for a proposed project should contain an erosion control plan. The plan specifies the control measures to be used to prevent erosion and sedimentation, the schedule for implementing these controls and identification of soil disposal procedures. The erosion control plan also contains the calculation methods used to size the control measures, the design specifications for these measures (including maps and sketches) and an estimate of time of exposure of graded areas prior to implementation of the erosion controls. Recommended features of an erosion control plan are presented in Technical Memo No. 41 - "Requirements for Erosion and Sediment Control Plans."

All of the inspection requirements listed in Technical Memorandum No. 34 for improving grading ordinances apply to enforcing erosion control plans. In addition, the ability to comprehend an erosion control plan and to inspect a project for compliance with design specifications and the project schedule is implied.

The Role of Construction Site Inspection

Erosion control at construction sites is primarily regulated through building and grading permits as administered by the applicable jurisdictions. The ordinances which create these permit programs also have provisions for plan checks and site visits by regulatory personnel to inspect the implementation of erosion control measures and to assess the effectiveness of erosion control. In some jurisdictions, inspectors will consult with prospective builders to determine erosion potential and the need for a grading permit.

Thus, the plan reviewers and construction inspectors are in a key position to advise the public and builders on precautionary measures prior to construction; to enjoin the applicable performance standards during construction; and to recommend remedial measures to correct problems.

To effectively perform erosion control duties, a plan reviewer or construction inspector must have training and experience to enable him or her to do the following:

- recognize the conditions that are the precursors to erosion problems such as steep slopes, erodible soils, unstable ground formations, ground disturbances and water seepage areas;

- recommend preventive measures to reduce or preclude erosion and sediment problems before they begin;

- evaluate the severity of observed erosion problems and prescribe the steps and timing necessary to control it;

- evaluate compliance with design specifications for measures put in as part of an erosion control plan or permit requirement;

- comprehend erosion control plan components, their relationship, relative effectiveness and optimum scheduling; and

- administer enforcement of the appropriate control measures when environmental damage has occurred.

Implications To Construction Site Inspection

The following effects may be caused by the enactment of more comprehensive grading ordinances and the requirement for erosion control plans:

- more frequent and thorough inspections for erosion problems;

- inspection of all projects with grading permits prior to rainy season (September-October) to ensure implementation of wet season erosion controls; and

- demand for more trained inspectors for erosion problems either permanently, or seasonally, based on the first two effects.

Meeting the Demand for More Construction Inspectors

With the implication that more inspectors trained in erosion control would be needed, local counties (surveyed in Section II of this memo) were queried for their preference in hiring new fully-trained personnel or training inspectors and other staff members in a training program. Most of the jurisdictions responded that they would send their own personnel to a training program if it were available. This would increase the capabilities of their staff and perhaps reduce the need to hire new persons. An annual update session on erosion controls for inspectors was also welcomed by most jurisdictions.

V. CRITERIA FOR INSPECTOR TRAINING PROGRAMS

Construction inspectors, plan reviewers and builders generally have limited training in erosion control and no training programs for this specific subject are available in the Bay Area. With improvements to local grading ordinances and requirements for erosion control plans, the need for trained personnel and a training program in soil erosion and sedimentation problems is evident.

This section reviews existing training programs for erosion control, proposes, develops and costs out a Bay Area erosion control training program and examines program recognition and certification.

Existing Training Programs for Erosion Control

Five training programs for erosion control developed by federal, state and county highway, public works and water resource departments were reviewed. The agencies surveyed included Caltrans, Santa Cruz Soil Conservation Service, Montgomery County, Maryland, and the Water Resources Administration of the Maryland Natural Resources Department. Table 2 lists the program type, length, components, topics and certification, if any, for each program. Examples of program announcements and contents are attached in Appendix B.

The jurisdictions using the programs described in Table 2 stated that the most important features were the handouts, slide shows, and field trips. Handouts should list guidelines for structural and vegetative practices. In addition, a field guide was suggested which would serve as a check list for the inspector to use at each site to determine the

Table 2. SURVEY OF INSPECTOR TRAINING PROGRAMS FOR SOIL EROSION SEDIMENT CONTROL

City/County Agency	Program Type	Length	Components	Audio/Visual	Directed to: (topic)	Certification
CalTrans	Workshop (given in 1978)	2½ days	• Elements of erosion • Field practice • Erosion impact assessment and mitigations • Field trips	Slide program	Highway erosion control Site specific Mostly CalTrans employees	Certification of Attendance
Maryland Water Resources Dept. Water Resources Admin.	Workshop	1 day	• Workbook • Guideline handbook • Materials and controls handbook • Standards and specifications • Field trip	Slide program, with tape and visual displays	Const. industry & govt. mgmt. agency supervisory personnel Mandated by law	Certification of attendance
Montgomery County, Maryland Construction Code Enforcement Division	"In house" for county inspectors. No "formal" program.	Variable	Review of Building Codes, inspection and engineering manuals	None	Public works people -inspectors Some cross training (construction fields)	None
Santa Cruz Soil Conservation Service	Workshop	4 sessions, each ½ day	Pamphlet and workbook Field trips Only ≈2 hours in class/session	Slide presentation	Training is directed to fit into ordinance specifications, eg., ag. consultants, grading & building contractors, engineers, govt. officials, landscape architects, consultants.	Certificate of training. Compiled list of those who have taken the course.
Caltrans	Workshop (given in 1978)	1 day	• project scope veg. & non-veg. considerations • project scheduling • focus on existing roads and slope • problems • field trip	films	Mitigation measures for developers (mostly highway people); also to landscapers; engineers, techs. developers	None

needed controls. Slide shows should illustrate problems within the jurisdiction as well as the specific control measures for each problem. It is important to use slides of local conditions, as different regions have geologic and soil problems specific to that region. For this reason, field trips are an essential component of any inspector training program. Table 3 illustrates the components of selected training programs. The programs ranged from one to two days. The Santa Cruz training program is relatively comprehensive and focuses on development and control of steep hillsides.

Proposed Bay Area Training Program

Based on training programs and workshops held by various agencies, a training program on erosion control for local use could be developed. A suggested training program is presented in Table 4 covering erosion problems and causes; principles and practices of erosion control; erosion and sediment control plans; and program compliance and enforcement. The program would run 2-3 days and be divided into four sessions, sessions 2 and 3 are the heart of the training program and would probably run longer than the other sessions due to the larger amount and technical content of the material to be covered. The program would conclude with an examination and a problem set. A certificate would be awarded upon satisfactory completion of the training program.

The estimated cost to develop and conduct a Bay Area Training Program is presented in Table 5. The initial costs to develop a program are approximately $92,000. Operations costs for each time the program is offered is estimated at $4,000. The operation cost may vary if the program is given to a smaller group (less than 75 people).

Alternative Methods for Conducting Training Program

In setting up a training program in the San Francisco Bay Area, there are several alternatives for developing, producing, conducting, and paying for a comprehensive training course:

1) Each city county could direct their planning or building department to prepare resource materials and a slide show and conduct a training program.

2) Each city/county could hire a consulting firm to develop and present the program.

3) Several cities/counties could cooperate and produce one program to be used by all those involved.

4) Community colleges which offer construction inspection courses could develop additional training for erosion control within their present programs.

5) ABAG could develop a program with the suggested

TABLE 3
COMPONENTS OF SELECTED TRAINING PROGRAMS

Program Sponsor	Program Components
Santa Cruz SCS 4 half-day sessions	Sessions 1 and 2 Principles and Practices of Erosion Control o Soil Erosion Processes o Factors That Contribute to Erosion Hazard o Sizing up Erosion Problems (includes "Checklist for Erosion Hazard at Construction Sites" and "Guidelines for Erosion Control on Construction Sites") o Erosion Control Principles for Roads on Steep Hillsides o Grading and Drainage Control on Roads o Guidelines for Landslide Hazard and Control o Summary of Methods and Costs of Common Erosion Control Practices o Temporary Erosion Control on Newly Reshaped Soils o Preserving Natural Vegetation Session 3 o Water Cycle o Stream Erosion and Control o Sediment Processes and Control (Catchbasins) o Erosion Control Planning o Site Design o Impacts of Road and Roof Runoff o Use of Vegetation To Control Erosion o Field Trip: Erosion, Grass/Legume Planting Session 4 o Soils and Soil Formation o Soil Characteristics Important to Erosion Control
Maryland Dept. of Natural Resources (one day session)	Introduction o Maryland Waters: o The Need to Protect o Sediment: Resource or Pollutant? o From Rainfall to Muddy Waters o Sediment Transport o Sediment Deposition Erosion and Sediment Control o Planning o Erosion Control o Vegetative Stabilization o Sediment Control o Control Maintenance o Control Effectiveness o On-Site Responsibilities
Caltrans (mostly highway oriented; one-day session)	Erosion Control Seminar o Regulations, Standard Specifications, Environmental Impacts of Erosion from Construction Activities o Erosion Processes and Mitigation o Erosion Control Plans Checklist

TABLE 4
BAY AREA TRAINING PROGRAM*

Program Components	Comments
SESSION 1 - PROBLEM STATEMENT	
o Introductory quiz	
o Causes of Erosion and sedimentation	o Audio visual slide presentation
o Problems caused by Erosion and sediment	o Ecological, flood hazard, public safety, economic, aesthetics
o Need for public and private erosion controls in urbanized areas	
o Examples of local erosion problems	o Slide presentation of problems in ABAG region
o Costs of controlled vs uncontrolled erosion and sedimentation	o Case studies in foothill and flatland communities o Costs of drainage system and water way maintenance compared to on-site erosion control
SESSION 2 - PRINCIPLES AND PRACTICES OF EROSION CONTROL	
o Assessing on-site erosion control needs	o Site inspection, use of topographic, soils and geology maps
o Principles for control of runoff and sediment during construction	o Field trip
o vegetative methods of soil stabilization	o Soil preparation/fertilization o Seed selection o Mulches and their application o Relative effectiveness
o Structural measures	o Temporary measures o Engineered methods typical for region (sediment basins, diversions, outler protection rip rap, etc.) o Control measures maintenance o Comparative effectiveness
SESSION 3 - EROSION AND SEDIMENT CONTROL PLANS	
o Erosion control planning during the permitting process	o Process for plan development o How to evaluate a plan
o Relationship to grading and building permits	
o General performance criteria and planning data requirements	o What info does developer provide o Plan inspection and approval (may include checklist) o Info/referral service
o Examples of erosion control plans (case studies)	o Small-unit development o Moderate unit development o Large unit development
SESSION 4 - PROGRAM COMPLIANCE AND ENFORCEMENT	
o Regulatory compliance tools	o Bonding, stop work orders, letter of credit, inspection fees
o Non-regulatory compliance tools	o Inspection follow-up, technical assistance
o Performance standards and compliance	
o Relationship between compliance	
o Final examination with example problems	

* Suggested 2-3 day training program

components and either make it available for use by the cities and counties or could present it as a "road show."

There are advantages to each proposal and each can be considered feasible. Proposals 1 and 2 would allow for relative autonomy of each jurisdiction. In addition, slides and brochures could be specific to the exact area for which inspectors are responsible. These two proposals require each community to invest considerable sums of money to develop similar types of programs. The programs would not be standardized and may vary widely in emphasis with no assurance of adequacy. The third alternative allows for the same advantages as the first two and since several cities or counties could work together, economies of scale exist and lower development costs are incurred.

Alternative 4 could produce a standardized course, and because it would be given at a community college, it would allow regular access for interested persons. The feasibility of this alternative is governed by the available funding for the construction program at each educational institutional based on local and state revenues.

Alternative 5 could produce a standardized and well-developed training program that would include relevant national, state amd instructional material and be designed to be applicable to local communities. ABAG is currently seeking funding for conducting a training program covering the amount shown in Table 5. The funds tentatively would be available as part of the 1980-81 EPA grant for the 208 Water Quality Management Program. The program would be developed and brought to local communities for presentation and training.

Program Recognition and Certification

Completion of the erosion control training program can be recognized by a certificate of attendance or by a certificate of satisfactory course completion.

The simplest form of recognition is a certificate of attendance. This implies that the attendee has been exposed to the major components of erosion control but does not connote expertise.

If the training program concluded with an examination and a problem set, a passing score on the examination would lead to a certificate of satisfactory course completion. This connotes a level of proficiency in recognizing erosion control problems and ability to work out solutions.

The training program could be developed and conducted in collaboration with an educational institution or a professional society such as the American Public Works Association, the Soil Conservation Society of America or the American Society of Erosion Control Engineers. Joint development has the advantage of supplementing the program with

TABLE 5
ESTIMATED COSTS TO DEVELOP AND CONDUCT
BAY AREA TRAINING PROGRAM

Program Components	Estimated Costs
INITIAL COSTS	
o Program Development (includes sessions, material for training manual, slide show, consultants, etc.)	$53,000
o Training Manual (includes typing, editing, layout and publication)	18,000
o Promotion (includes, preparation, publication and general distribution of informational material and announcements)	21,000
Subtotal Initial Costs	92,000
PROGRAM OPERATION	
o Conduct 3-day training program (including instructor, assistants, consultants, administration, public announcements and facilities).	4,000

professional expertise and can give the program professional and academic recognition. If the program is comprehensive and rigorous, it could provide credit towards the experience requirement for professional registration in construction inspection.

Training in erosion control should be part of the construction inspection curricula at local colleges. Once a program is fullly developed, it could be given on a regular basis at a local college. This would make the training program accessible to persons in construction trades, inspectors, and others in related fields.

VI. COROLLARY INFORMATION PROGRAMS

Regulatory programs and site inspection for soil erosion and sedimentation control can only be effective if all those who come in contact with erosion have a basic understanding of the problem and why its control is important. These persons (building contractors, architects and landscape architects, developers, engineering consultants and individual builder-owners) need to understand that they have a role in preventing erosion and that any investment of time and money in preventive measures will be worthwhile.

Lack of planning and erosion controls can lead to economic and regulatory consequences that can directly or indirectly affect property owners and persons involved in construction or landscaping. Uncontrolled erosion can lead to property damage and decrease in property values. Siltation in streams and reservoirs can require expensive dredging with costs borne by the taxpayers. In areas where the erosion problem is severe, area residents could be assessed an individual share in the clean-up costs and be subject to regulations and stiff fines for contributing to erosion.

Clearly, persons facing or contributing to erosion problems need to understand not only the problem, but the undesirable potential consequences as well. If the implementation of basic control measures to combat erosion can reduce the environmental and economic burdens, then the contribution of concerned individuals can be worthwhile.

A corollary information program can be effective in bridging the gap between a well-intentioned erosion control program or ordinance and an indifferent or uninformed public. Program components should include the preparation and distribution of resource materials, increasing public awareness and conducting information programs as appropriate.

Resource Materials

Public information can be presented in brochures, posters and slide programs. Brochures should be clearly written in non-technical language describing why erosion problems occur, why they are crucial and how they

can be prevented. Pictures should be included to illustrate problems and where they occur. Several such brochures have been prepared by the USDA Soil Conservation Service and other regional agencies such as Tahoe Resource Conservation District; but as these address different soil and topographic conditions, pamphlets should be designed specifically for the Bay Area. Topics should include structural practices as well as vegetative control measures. Examples of types of information pamphlets are shown in Appendix C.

Awareness Program for Specific Groups

An awareness program aimed at contractors and homeowners performing groundwork and landscaping can be designed with brochures and slide programs. This type of work can involve gardening, installing irrigation systems, landscaping and building retaining walls. It is particularily important to get clear and correct information on erosion control practices to these people, especially owners of new homes who are just beginning to landscape bare yards. Pamphlets can be posted in the city or county building permit desks, nurseries, lumber yards and building supply stores for general dissemination. Slide-tape shows can provide a concise method of education on control problems and suggested controls for groups. Such groups include homeowner associations as well as individual builder-owners. Public works and planning staffs and community college classes on building inspection also provide a large audience. The slide show and pamphlet can be integrated into a "road-show" and taken to meetings of those groups.

General Information Program

Public awareness of the problem is only the first step in controlling and preventing erosion. Next, people have to see and hear about current problems and how they should have been prevented. Local news media is an appropriate avenue through which information can be made public because of its enormous audience. Newspapers and television news can illustrate problems when they occur, therefore the cause and effect are made current and immediate. In addition, soil erosion and sedimentation control can be made interesting through panel discussions and radio talk shows, if interesting speakers are provided. Agency staffs should have contacts at local newspapers, TV and radio stations so that when a problem occurs, such as landslides related to rains, the media can be contacted quickly.

Information Program Costs

A basic information program should consist of the following components:

- Pamphlets or brochures for the general public,
- Printed material for specialized audiences,

- Slide show for the general public on soil erosion problems,

- Workshops for public officials, architects, consultants, contractors etc.,

- Media relations and general information dissemination,

Costs for three types of programs by increasing level of effort are shown in Table 6. These costs are broken down by funds for materials and personnel effort. Each break-down assumes a certain amount of local agency participation and cooperation.

TABLE 6. INFORMATION PROGRAM COSTS

Budget Level and Basic Program Components	Costs	Person-months
1. Low Budget		
o Program for small community	$ 800	3
o With use of shared pamphlets and slide show prepared for all local agencies by an outside party	325	1.25
2. Moderate Budget		
o Medium Sized Community with addicion of slide show for technical audiences	3,700	5
o With use of shared pamphlets and slide shows prepared for all local agencies by an outside party	1,350	1.6
3. High-impact Budget		
o Larger communities with addition of slideshow for technical audiences and an advisory committee	6,400	9
o With use of shared pamphlets and slide presentations	4,800	4.8

APPENDIX A. CONSTRUCTION INSPECTION AND INSPECTOR TRAINING PROGRAM SURVEY FORM

SOIL EROSION AND SEDIMENT CONTROL INSPECTOR TRAINING PROGRAM
COST ASSESSMENT

ARE THERE ANY INSPECTOR TRAINING PROGRAMS NOW IN YOUR JURISDICTION?______________

IF NOT, ARE YOUR PLANNING TO DEVELOP ANY IN THE NEAR FUTURE?______________

WHAT TYPE OF TRAINING DO YOUR GRADING INSPECTORS HAVE NOW? DO THEY PERFORM THIS SOLELY, OR IN CONJUNCTION WITH OTHER DUTIES, I.E. BUILDING INSPECTION?

____

____

____

CAN YOUR STAFF HANDLE INCREASED NUMBER OF EROSION CONTROL INSPECTION?

_____10% _____20% _____40% _____60% _____100%

IF AN EROSION CONTROL INSPECTOR TRAINING PROGRAM WERE PUT ON ANNUALLY BY ABAG OR SOME OTHER GROUP, WOULD YOU SEND YOUR STAFF TO IT OR WOULD YOU PREFER TO HIRE INSPECTORS FROM OUTSIDE?______________________________

____

WOULD YOU SEND YOUR INSPECTORS TO AN ANNUAL UPDATE SESSION?______________

WHAT TYPE OF PROGRAM DO YOU HAVE: WORKSHOP WITH SLIDES, PROGRAMMED LEARNING, OR BOOKLET?______________________________

____

____

HOW MANY PEOPLE HAVE GONE THROUGH THE PROGRAM SINCE ITS START?______________
IN THE LAST YEAR?______________________________

WHAT PROFESSION ARE THOSE PEOPLE IN?______________________________

____

DOES YOUR DEPARTMENT CHARGE A FEE FOR THE PROGRAM?______________________
HOW MUCH?______________________________

HOW MUCH DOES THE PROGRAM COST YOUR DEPARTMENT, PER PERSON?______________
(A ROUGH ESTIMATE IS SATISFACTORY)

WHO SET THE EDUCATIONAL CRITERIA? WHAT ARE THEY?______________________

____

____

____

____

____

WHAT ARE PEOPLE QUALIFIED TO DO UPON COMPLETION OF THE PROGRAM? DO THEY RECEIVE A CERTIFICATE, DO THEY HAVE TO TAKE A TEST?______________________

____

____

____

WHO ORGANIZED THE DEVELOPMENT OF THE PROGRAM?

HOW DID YOU HANDLE INSTITUTIONAL CONSIDERATIONS? I.E. REGISTRATION REQUIRED FOR ENGINEERS?

PROGRAM COST BREAKDOWN:

COST PER PERSON TOTAL

SLIDE PROGRAM

PAMPHLET: WRITING COST
PRINTING COST

LECTURER TIME

ROOM/LECTURE HALL RENT

COST OF DEVELOPMENT OF PROGRAM IN GENERAL

OTHER MISCELLANEOUS COSTS

COST OF HIRING INSTRUCTOR
COST OF INSTRUCTORS TRAINING
ARE OTHER JURISDICTIONS TAKING ADVANTAGE OF THIS PROGRAM, OR HAVE THEY USED IT AS A MODEL FOR THEIR OWN PROGRAM DEVELOPMENT?
WHAT JURISDICTIONS?

THANK YOU FOR YOUR ASSISTANCE

PLEASE RETURN TO:
ALISON L. SMITH
ABAG
HOTEL CLAREMONT, BERKELEY CA 94705

IF YOU HAVE ANY QUESTIONS, CALL 841-9730, x-235

ANNOUNCEMENT

TO ASSIST IN THE EFFORT AGAINST SEDIMENT POLLUTION OF MARYLAND WATERWAYS THE STATE OF MARYLAND DEPARTMENT OF NATURAL RESOURCES WILL CONDUCT

A STATEWIDE EROSION AND SEDIMENT CONTROL TRAINING PROGRAM

MARYLAND SEDIMENT CONTROL LAW 08.11.03.01 REQUIRES:

"...after July 1, 1980, any applicant for sediment and erosion control plan approval shall certify to the appropriate jurisdiction that any foreman, superintendent, or project engineer who is in charge of onsite clearing and grading operations or sediment control associated with a construction project will have a certification of attendance at a Department of Natural Resources approved training program for the control of sediment and erosion before beginning the project..."

A statement of certification will be required on erosion and sediment control plans.

Notification

During the fall, 1979, firms engaged in clearing and grading operations or sediment control will be notified as to required dates and locations of attendance at a designated training center.

Training Program

When - December 1979 to June 1980

Where - At designated training centers within each county and Baltimore City

How Long - One day training session

Administration - State of Maryland, Water Resources Administration

For More Information Contact

Gary C. Stanton
Watershed Permits
Water Resources Administration
Tawes State Office Building
Annapolis, Maryland 21401

Telephone (301) 269-2265

(turn over for training session agenda)

TRAINING SESSION AGENDA

(one day session)

Introduction

MARYLAND WATERS: A NEED TO PROTECT

SEDIMENT: RESOURCE OR POLLUTANT?

From Rainfall to Muddy Waters

EROSION: ON DISTURBED SITES, WHEN IT RAINS--LOOKOUT!

SEDIMENT TRANSPORT: OVERLAND STREAMS OF MUD!

SEDIMENT DEPOSITION: OUR STREAMS TAKE A BEATING! WE AND THE FISH LOSE

Erosion and Sediment Control

PLANNING: DOES THE PLAN FIT THE SITE?

EROSION CONTROL: KEEPING SOIL WHERE IT BELONGS.

VEGETATIVE STABILIZATION: A LITTLE GRASS GOES A LONG WAY.

SEDIMENT CONTROL: INTERCEPTING AND COLLECTING MUD.

CONTROL MAINTENANCE: MAINTAINING CONTROLS IN WORKABLE SHAPE.

CONTROL EFFECTIVENESS: OFFERING ASSURANCES THAT CONTROLS WORK.

ON-SITE RESPONSIBILITIES: EARTH MOVERS AND INSPECTORS - WHO IS RESPONSIBLE FOR WHAT?

Alameda County Public Works Agency AND

ABAG ASSOCIATION OF BAY AREA GOVERNMENTS

PRESENT:

A WORKSHOP

EROSION AND SEDIMENT CONTROL IN URBANIZING AREAS

DATE:

APRIL 19, 1979

TIME:

8:00 A.M. TO 5:00 P.M.

PLACE:

HORIZON ROOM, HOTEL CLAREMONT,
ASHBY AVENUE AT DOMINGO AVENUE,
BERKELEY, CALIFORNIA

Presented by

Alameda County Public Works Agency
and
Association of Bay Area Governments (ABAG)
in cooperation with

American Planning Association
American Public Works Association,
Northern California Chapter
American Society of Civil Engineers, San Francisco Section
Association of Environmental Professionals,
S.F. Bay Area Chapter
Council of Bay Area Resource Conservation Districts
Regional Water Quality Control Board, S.F. Bay Region
U.S.D.A. Soil Conservation Service
United States Environmental Protection Agency

ABAG ASSOCIATION OF BAY AREA GOVERNMENTS
Hotel Claremont
Berkeley, CA 94705
(415) 841-9730

FIRST CLASS
U S POSTAGE
PAID
Permit No 662
Berkeley CA

PURPOSE

The purpose of this workshop is to present information on two key aspects of erosion control:

- Design, installation and maintenance of erosion control measures in land development
- Development, implementation and enforcement of erosion control regulations

The workshop is oriented towards both public agency staff and the private sector concerned about controlling erosion in developing areas. The intended audience includes county and city planners, public works engineers and inspectors, land developers, consultants and Resource Conservation District staff.

This workshop will mark the beginning of the 1979-80 Surface Runoff Work Program for the San Francisco Bay Area. This work program is a continuation of the initial two-year planning process in which erosion and sedimentation were identified as the major surface runoff problems in the Bay Area.

- For information contact
  ABAG - Steven Goldman 841-9730
  Alameda County - P.E. Baker 881-6221

AGENDA

MORNING SESSION - Moderator: H.A. Flertzheim, Jr.
Director of Public Works,
Alameda County

8:00 - 8:30	Registration and distribution of workshop materials. Coffee provided.
8:30 - 8:35	*Welcome*, Revan Tranter, Executive Director, ABAG.
8:35 - 8:55	*Introduction*, Steven J. Goldman, Coordinator of County Surface Runoff Planning, ABAG
8:55 - 9:15	*The Need for Erosion and Sediment Control in Urban Areas*, H.A. Flertzheim, Jr.
9:15 - 10:00	*A Case Study of Erosion and Sediment Control Efforts in Alameda County*, Patrick E. Baker, Engineer/Scientist, Alameda County Public Works Agency.
10:00 - 10:30	Coffee break. Preceding speakers will be available for questions and informal discussion.
10:30 - 11:00	*Regulating Erosion and Sediment Control - The Maryland Experience*, Robert Seely, Chief, Field Services, Division of Construction Codes Enforcement, Montgomery County, Maryland.
11:00 - 11:15	*The Need for Erosion and Sediment Control in the Bay Area - A Regulatory Agency's Viewpoint*, Roger James, Assistant Executive Officer, Regional Water Quality Control Board, San Francisco Bay Region.
11:15 - 12:00	*The Erosion and Sediment Control Plan - An Overview*, Stephen M. Boysen, SCS, Maryland (Principal author, Standards and Specifications for Soil Erosion and Sediment Control in Developing Areas).
12:00 - 1:00	Luncheon -- Speaker: *Erosion Control in Urbanizing Areas -- A Developer's Viewpoint*, William J. Watson, President, Presley of Northern California.

AFTERNOON SESSION - Moderator: Dean Macris
Associate Executive Director,
ABAG

1:00 - 2:00	*Design, Installation and Maintenance of Erosion and Sediment Control Measures*, Stephen M. Boysen.
2:00 - 2:20	*Vegetative Methods for Site Stabilization*, Robert Slayback, SCS Plant Materials Center, Lockeford, California
2:20 - 3:00	*Design, Installation and Maintenance of Erosion and Sediment Control Measures - Continuation of 1:00 p.m. Discussion*, Stephen M. Boysen.
3:00 - 3:30	Coffee break. Preceding speakers will be available for questions and informal discussions.
3:30 - 4:15	*Implementation and Enforcement of the Erosion and Sediment Control Plan*, Robert Seely.
4:15 - 4:45	*The Liability Question*, Jack Levitan, Attorney, Wendel, Lawlor, Rosen and Black (former County Counsel, Alameda County).
4:45 - 5:00	*Summary and Critique*, Peter Chiu, Surface Runoff Program Manager, ABAG
5:00 - 6:00	No host cocktail hour.

REGISTRATION

NAME(S) ______________________________

____

____

ADDRESS ______________________________

____

____

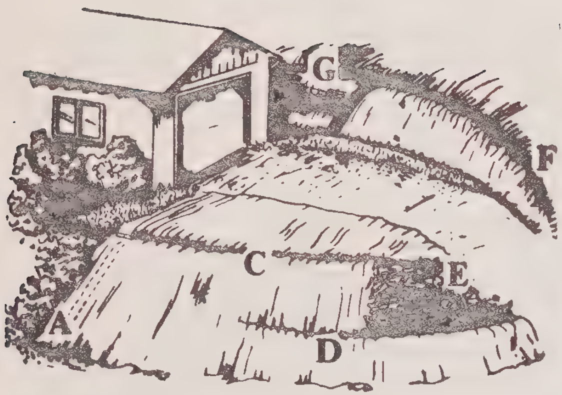
AFFILIATION ______________________________

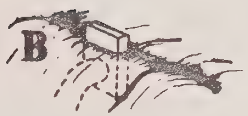
____

____

The registration fee is $5.00 per person and includes lunch. Make checks payable to Association of Bay Area Governments. Lunch cannot be guaranteed for registrations received after April 12.

Enclosed please find $______ for registration of the above ________ persons.





A Sheet metal or standard pipe used to drop water down steep slope (Pipe buried in ground. See Detail B)

B Headwall at upper end of pipe

C Construct a small berm along top edge of slope when area can be sloped toward a paved area or to a pipe down the slope.

D Diversion ditch carries water away from bank to paved driveway.

E Straw, peat moss or wood chips and seed to grass or plant perennial ground cover. Under severe conditions straw can be held in place with chicken wire or some other type of plastic or jute mesh held down with stakes.

F May need paving or pipe on steep sections.

G Plastic sheets will prevent bank erosion through first winter.

AFTER YOU BUILD

With construction completed, the protection of your investment should be a priority.

Your landscaping plan will probably include slope stabilization. Use grasses, trees and shrubs adapted to the site for their aesthetic value.

Protect Your Investment: Mulch, Landscape. . . .

To protect the exposed soil around your house, mulch and landscape your site as soon as possible after construction is completed. Until you have a chance to put in a permanent lawn or ground cover, plant an annual grass to hold the soil and retard erosion.

Steep slopes that need extensive work, such as retaining walls, regrading or landscape planting, can be protected temporarily by covering them with plastic sheets. Channel rainfall away from areas subject to erosion.

Seed and mulch the cut and fill slopes along your driveway that will not be extensively landscaped, with a mixture of annual or perennial grasses to provide long-term protection from erosion.

Get Advice

For further information and for technical assistance on conservation measures for homesite construction, contact your local Resource Conservation District or Soil Conservation Service.

-October 1979-

HOMESITE CONSTRUCTION and MAINTENANCE TIPS

U.S. DEPARTMENT OF AGRICULTURE
Soil Conservation Service

BEFORE YOU BUILD

You can make long-term dollar savings through careful home-site selection and planning that will prevent construction and maintenance problems. The more suited your property is to building, septic system and road construction, the less it will cost to develop. Also, by devising a construction plan that includes conservation measures, you will protect and maintain your property during and after construction. Some of the factors to consider in the planning process include:

Slopes

Excessively steep slopes can require large, expensive movement of soil for the house pad and road. The resulting cut and fill slopes erode easily. If the site for the septic system and leach field is on a slope greater than 30 percent, you will need to follow special county requirements for its construction. Roads with steep grades (eight percent or more), are difficult to protect from erosion, and may require the extra expense of paving.

Erosion Control

Plan erosion control measures before you begin grading. Temporary seeding and mulching may be needed to protect the construction site, completed work, or downstream development. Structures, pipes, rock and paving may be a necessary component for adequate erosion control on your property. Pre-planning will enable you to obtain the necessary materials and equipment to accomplish the needed improvement. Preparation and application of erosion control measures can be considered an insurance policy in the protection of your real estate investment.

Grading

A grading plan needs to be developed that includes measures to collect and dispose of on-site surface runoff.

Drainage

Drainage problems can occur from surface runoff from slopes above the site and on low, flat and naturally wet areas. Some soils stay soft or marshy all year long due to their proximity to stream channels, natural seeps, springs, drainage from septic tanks and irrigation ditches, etc.

Potential drainage problems must be solved to avoid possible flooding of the house or malfunction of the septic system.

Soils

Soils conditions vary with building sites. Soils characteristics that could relate to your potential site problem are: depth - texture - permeability and percolation - slope - depth to water table - flooding - stoniness and rock.

Bedrock below shallow soil is common in the Sierra Foothills. Construction on these soils sometimes requires blasting or jackhammer work.

Further limitations could include the shrink-swell behavior of soils, plasticity, corrosivity of soils, excavation difficulties and septic tank installation.

Putting in septic tanks in soil less than 48 inches deep limits the effectiveness of the leach field and increases the installation cost. Contact your county health department for regulations on site selection and installation of septic tanks.

Severe Erosion

Earth for this house pad was moved during the rainy season. Consequently, sediment washed from the site filling the drainage pipe across the street.

Before and After

Rain washed soil off this slope before the homeowner installed a retaining wall for stabilization.

A LOOK AHEAD . . .

At the current rate of growth in Santa Cruz County, our population will double in the next 20 years. Our land and natural resources will not increase.

The United States Department of Agriculture said in a recent report, "If we are to survive, we must look to the land--its soil, water, plants, and animal life--with renewed interest and develop a will to support a comprehensive program of environmental management.

WE NEED YOUR HELP! . . .

Because resource conservation is worth very little without people willing to recognize the need and to work together.

INTRODUCING YOUR SCCRCD DIRECTORS:

Ward Hastings, Pres., Santa Cruz
Sam Sakamoto, Vice-Pres., Soquel
Jim Marshall, Treas., Watsonville
Roger Wicht, Summit Road
Frank Siri, Watsonville

Sylvia Blazo, Recording Secretary
Lisa King, Clerk/Typist
Steve Singer, Watershed Specialist
Terry Butler, Watershed Consultant
Laura Strohm, Conservation Volunteer

The directors also have an Associate and Jr. Board of Directors to assist them with their programs.

SOIL CONSERVATION SERVICE STAFF:

Rich Casale, Soil Conservationist

WHERE TO GET HELP! . . .

Find out more about local conservation programs by stopping by our office.

Santa Cruz County Resource Conservation District, 3019 Porter Street, P. O. Box 267, Soquel, California, 95073. Telephone: (408) 475-1303.

District meetings are held at the Conservation District Office on the fourth Monday of each month at 7:00 p.m. DST and 8:00 p.m. PST. The public is invited to attend and participate at all meetings.

Hope to see you there soon!

Santa Cruz County

Resource Conservation District

"PEOPLE HELPING PEOPLE
CONSERVE OUR NATURAL RESOURCES"

HURRY WHILE THE SUPPLY LASTS!

The soil in Santa Cruz County is becoming a limited resource. Don't wait to find out that conservation can save you time, money, and energy while you help protect soil, water, and related resources at the same time.

WE CAN HELP!

The people at the Santa Cruz County Resource Conservation District (SCCRCD) are busy promoting conservation programs to help people with their conservation needs.

WHAT IS SCCRCD?

SCCRCD is a public agency organized under state law responsible for conservation work in Santa Cruz County (excluding the four incorporated cities of Santa Cruz, Watsonville, Capitola, and Scotts Valley).

The district is managed by five non-salaried directors who are landowners in the district and who know local problems. Operating funds are mostly drawn from local sources.

SCCRCD rely on staff from federal and state agencies for trained manpower. Chief among the cooperating agencies is the Soil Conservation Service (SCS), an agency of the U.S. Department of Agriculture.

WE'RE HERE TO HELP YOU!

WHAT KIND OF HELP IS AVAILABLE?

Conservation assistance is available, free of charge, through the SCCRCD in cooperation with the Soil Conservation Service. This assistance can include the following:

1. SOILS INFORMATION: Soils information for the entire county is contained in a recent interim report prepared by the SCS entitled, the Santa Cruz County Soil Survey Report. Soils information is useful for:

   A. Agriculture...The survey lists the capabilities and limitations of the soils, potential problems and conservation practices for substantial yields.

   B. Planners . . . The survey has basic data that can be used in making landuse and zoning decisions. It can also be used to define potential problems in planning areas.

   C. Developers and Builders...The survey can point out soil hazards at proposed construction sites, plan optimum development and insure adequate conservation during and after construction.

   D. Homeowners . . . Consider the soil first. Soil Surveys can help you too.

2. CONSERVATION ASSISTANCE: Professional conservationists are available to assist landusers with conservation needs, i.e. seeding recommendations, pasture and range management, erosion control practices, etc.

3. ENVIRONMENTAL EDUCATION: Conservation and environmental education assistance and materials is also available on request.

BENEFITS FROM CONSERVATION...

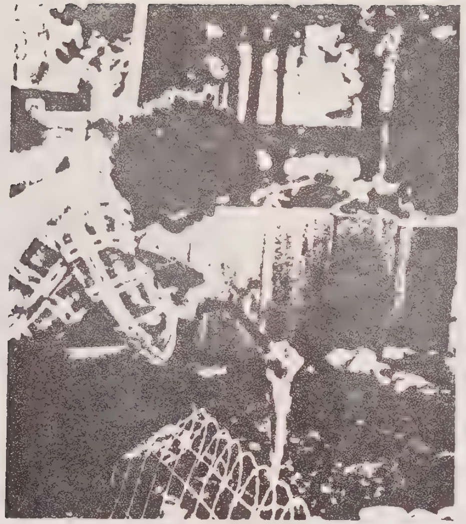
1. Economic gain. Landowners who practice sound management of land and water get higher returns than those who don't

2. Reduced costs. Effective resource management prevents damages and costly repairs.

3. Community improvement and economic development. Includes a stabilized base for agriculture, improved water quality and supplies, new opportunities for youth and recreation, a higher tax base and a continuing supply of high quality food.

4. Aesthetic values. Conservation enhances our environment, helps protect our resource base, and adds to the quality of our standard of living.

C-5



Vegetation establishment and growth are largely determined by irrigation.

Irrigating

— To avoid dryness, plan irrigation at the outset. Water all shrubs and trees at least three times in the first year and once or twice the second year. More frequent watering, up to once per week, will help. Water grass areas once a week following the initial establishment period during the first year. If the soil dries out in the upper inch or so, irrigate.

— Irrigation frequencies can be reduced during the second season. This practice allows plants to begin adapting to the natural water regime of the site, while providing adequate water for growth during the young growing stages. For landscape plants, continued irrigation will ensure more luxuriant growth.

— Coordinate water with weather predictions to prevent over-watering and erosion damage.

— Slow, deep watering will produce better growth than rapid surface watering.

Helpful Hints

— Try to prevent all foot and vehicular traffic across the revegetated area. Sod grasses can withstand some foot traffic after the first year.

— Apply five (5) pounds per 1,000 square feet of 16-20-0 fertilizer at the beginning of the second growing season to grass-seeded sites.

— Check the site for inadequate plant establishment or physical damage periodically throughout the year.

— Repair damaged areas by spreading new seed or by replanting the area. Fertilize and irrigate the soil following reseeding or replanting.

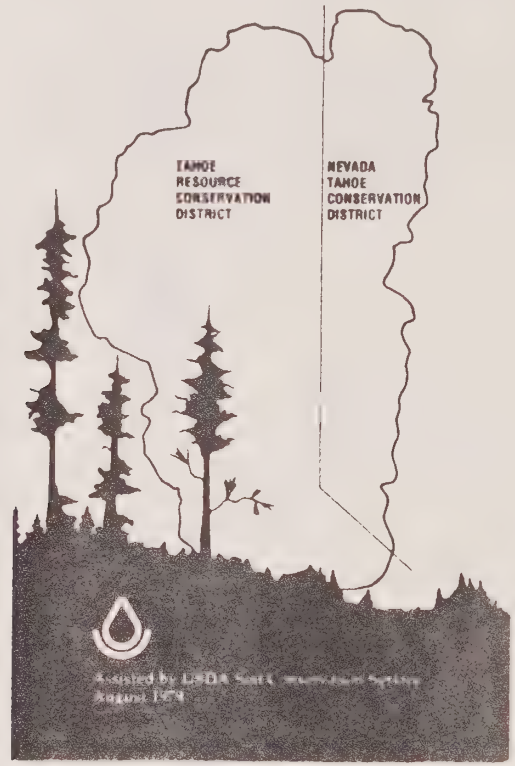
— Mulch all seeded sites. Mulch is a cover of clean, weed-free straw, placed over the seedbed. It reduces erosion and increases germination and good early growth. To protect the straw from wind and water damage, apply mulch to the soil evenly before anchoring. Generally, apply 50 pounds per 1,000 square feet. Hold straw into place with tackifier or with netting such as jute or plastic. Or, punch the straw into the ground with a shovel or crimping machine.

Need Technical Assistance?

The planting methods included in this guide provide step-by-step instructions. To obtain free planting assistance and lists of native plant nurseries, contact the following agencies.

Nevada Tahoe Conservation District
Tahoe Resource Conservation District
Soil Conservation Service, USDA
P.O. Box 10529
3552 Highway 50
So. Lake Tahoe, CA 95731
916-541-1496 or 541-5654

A PRACTICAL GUIDE FOR PLANTING In The Lake Tahoe Basin



Growing In Tahoe
— Difficult, Not Impossible

Landowners in the Lake Tahoe Basin often find it difficult to grow plants on their property. This is due, in part, to poor texture and lack of necessary nutrients in the Basin soils. High altitude, short growing season, and eroding cut and fill slopes further restrict plant establishment. Successful establishment of vegetation necessitates slope stabilization. This generally requires mechanical and vegetative measures.

Through testing numerous experimental plantings, researchers determined vegetation which requires little maintenance. These grow well on disturbed land such as construction sites and highway banks. The results of the experiments were used to design this guide for landowners, developers, and others who want to achieve successful revegetation.

Development and construction activities over the last two decades have increased erosion and sediment pollution. As vegetation is removed, soil containing nutrients and organic matter erodes by stormwater runoff. The runoff carries eroded soil into streams and the lake. Soil nutrients, detrimental to the waters of Lake Tahoe, cause algae growth along the shoreline, creating an unpleasant visual appearance. In addition, erosion removes fertile soil needed for successful plant establishment.

Native plants are recommended, because they require less care and have a higher survival rate than ornamentals. However, with proper care, it is possible to establish ornamentals (non-native) which can provide effective erosibn protection.

Property owners often find it difficult to successfully grow on slopes. The guidelines offered here will prove helpful.

This guide uses native plants for illustration purposes but includes information on growing ornamental vegetation in the Lake Tahoe Basin.

Although revegetation proves effective on denuded construction sites, landowners are encouraged to retain as much natural vegetation as possible during the actual construction period.

For information on how to retain vegetation, and how to stabilize soils before revegetating, consult "A Practical Guide For Building In The Lake Tahoe Basin." Contact the Tahoe Resource Conservation District in California, the Nevada Tahoe Conservation District in Nevada, or the Soil Conservation Service for copies. Offices are located at 3552 Highway 50, South Lake Tahoe.

Selecting Vegetation

In selecting vegetation types, consider the following:

— Is the planting site currently eroding?

If so, the site may require mechanical stabilization before you attempt revegetation. Often solving such conservation problems necessitates a combination of mechanical and vegetative measures. (See "A Practical Guide For Building In The Lake Tahoe Basin," available from your local conservation district.)

— What type of vegetation should be planted first?

Plant and establish native grasses before introducing shrubs or trees. Grasses grow quickly, require less initial maintenance than shrubs or trees, and can stabilize an eroding slope in less time. Irrigate grasses the first year to help ensure their establishment. If desired, add trees and shrubs at a later time.

— What type of atmosphere should the vegetation create?

In addition to offering color variety, vegetation can create shade in a sunny area, conceal unpleasant sights, muffle sound, attract wildlife, and provide protection from the wind. Consult a local nursery or landscaper for additional information on appropriate vegetative types for various applications.

Recommend Native Vegetation

The following section describes the perennial grasses, shrubs, and trees which grow well in the Lake Tahoe Basin, and their site requirements. At times, native plants will be hard to obtain. However, their survival rates are higher than ornamentals, and the landowner can avoid continual replanting. Other types of grasses, shrubs, and trees than listed below — both native and ornamental — will grow with proper care in the Lake Tahoe Basin. However, the vegetative species listed are recommended because of the excellent results obtained from their use.

Choosing Grasses

The perennial grasses shown grow effectively in the Lake Tahoe Basin. These grasses are used in various mixtures, rates and applications. They require little maintenance, other than first year irrigation, and provide effective erosion control and stabilization of soils at slopes of two feet horizontal to one foot vertical (2:1) or less.

Durar hard fescue

Luna pubescent wheatgrass (Agropyron trichophorum)

Cicer milkvetch

Tegmar intermediate wheatgrass (Agropyron intermedii)

The most commonly used grass mixture is as follows:

Planting Materials	Lbs/Acre	Lbs/1000 Sq. Ft.
Tegmar intermediate wheatgrass or Luna pubescent wheatgrass	25	.75
Durar hard fescue or Sherman big bluegrass	10	.50
White Dutch clover, yellow sweet clover, or Lutana cicer milkvetch	10	.50

Consult your local conservation district or Soil Conservation Service for other mixtures, rates, or applications

See Inside

Seeding And Planting

Successful revegetation requires careful preparation of the plant site. Site preparation primarily involves ensuring an adequate supply of good topsoil and adjusting the property slope, if necessary, to permit effective plant growth.

On undisturbed areas and in instances where the original quantity of topsoil remains after disturbance to property, seeding proves effective without any site modification other than fertilization.

When construction practices or erosion deplete topsoil, add new topsoil before seeding. The amount of topsoil needed will vary depending on site conditions.

Before disturbing areas, collect and stockpile topsoil (including all surface organic matter such as leaves and needles). After completing the project, redistribute the stockpiled topsoil over the site. Because of the difficulty in establishing vegetation, the existing vegetation should be protected before, during and after construction. To limit the construction work area size, erect temporary fencing.

Grasses

Plan to seed soon after preparing the site because wind and water erosion can quickly remove topsoil.

If preparing to seed or plant on a slope, round the top and bottom of the slope to prevent undercutting. The slope angle should not be steeper than two to one (2:1). Loosen compacted soil to an approximate depth of four (4) inches.

Before planting, carefully follow the guidelines presented in this brochure. Adequate seedbed preparation is a must.

Most homeowners utilize the broadcast method of seeding. To do so, scatter grass seed on top of the soil and then spread a one-half (1/2) to one (1) inch cover of seed or mulch. Mix seed and fertilizer together before broadcasting over the area.

Spread the seed by hand, or by using a push or "whirly-bird" seeder. Often hardware stores rent mechanical seeders. Seeds and fertilizer must be approximately the same size when using mechanical seeders.

Follow these procedures when seeding an area:

— Rake the area before seeding (approximately 1/2" deep). Do not damage existing vegetation when raking.

— Seed the area.

— Lightly rake the area to cover the seeds with a shallow layer of soil or mulch (approximately 1/2 to 1" thick).

— Mulch with wood chips or straw.

— Water the site lightly, being careful not to overwater and erode site. Keep the soil moist for three to four weeks or until grass is three (3) to four (4) inches high. Then continue to water at least once every two weeks for the remainder of the growing season.

Shrubs And Trees

After stabilizing slopes with grass, if desired, interplant trees and shrubs. Since they seldom grow from seed, use container or potted stock. Planting techniques will vary depending upon the age, species, and the season. In most situations, planting trees and shrubs in early spring, works best. Fall plantings are subject to frost heave.

The following should be kept in mind:

— Obtain fresh stock from a reputable nursery or supplier.

— Remove the container before planting.

— Dig a large hole for each plant. A general rule of thumb states to dig a hole two to three times the size of the container.

— Fill the hole with water and allow it to drain before setting in the fertilizer and plant.

— Place fertilizer in the bottom of the hole and cover it with one (1) to two (2) inches of soil.

— Loosen and straighten any crowded or coiled plant roots.

— Place the plant in the hole with roots straight down and backfill with good topsoil.

— Mulch with wood chips, bark, or compost.

— Irrigate without causing erosion, about once every three weeks. Cease irrigation several weeks before the onset of freezing weather to allow the plants to "harden" for winter dormancy.

Fertilizing

A continuing maintenance program will emphasize fertilization. The three most commonly used fertilizers include slow release, conventional (fast release) and organic. The types and applications of fertilizers vary widely, depending on plant species, topography, and season. Consult your local nursery or conservation district for more details.

When using fertilizer, do not use excessive amounts because over-fertilization damages native plants. When 500 feet or closer to any streamcourse or Lake Tahoe, reduce the application rate by one-half.

Prior to spreading fertilizer, make sure that you have the correct formula and application. Consult your local conservation district or nursery for details.

Grasses

The following commonly used formulas and rates apply to grasses:

— When fertilizing on slopes steeper than three to one (3:1), or in spring and summer, use only the conventional fertilizer (fast release). Steep areas or areas seeded during hot weather need the fast release of nutrients for rapid plant growth. Apply a formula of 16-20-0 at a rate of three and one-half (3½) pounds per 1,000 square feet.

— When fertilizing on areas flatter than three to one (3:1), or when applying fertilizer in the early spring or late fall, use either slow release or organic fertilizers. If you use slow release, apply a formula of 20-10-5 at a rate of five and one-half (5½) pounds per 1,000 square feet. If you use organic, apply at a rate of 450 pounds of manure or compost per 1,000 square feet and incorporate it into the top four (4) inches of soil.

— If you have trouble getting plants to grow, plant inspection or soil testing may reveal nutrient deficiencies. If this is the case, apply the fertilizer recommended in the soil test.

Shrubs And Trees

The following commonly used formulas and rates apply to shrubs and trees:

— Use slow release, pelletted fertilizer with shrubs and trees. The pellet releases nutrients slowly and sustains growth for a longer time. Pelletted fertilizers are available under several trade names. Compost, peat moss, or steer manure will also aid the plant's chance of survival.

— If the plant is less than one-half gallon capacity, place a five-gram pellet of slow release fertilizer, formula 20-10-5, two (2) inches below the bottom of the root mass. Cover the pellet with soil, and then plant. If the container is a one gallon size, place one 21-gram pellet, two 10-gram pellets or four five-gram pellets of slow release fertilizer, formula 20-10-5, two (2) inches from the root mass. Center 21-gram pellets under the root mass and space 10-gram and five-gram pellets around the root mass.

See Back

Choosing Shrubs

The following native shrubs are excellent choices for revegetation, if planted in the correct environment. When selecting, match requirements to planting site characteristics.

Greenleaf manzanita
(Archostophylos patula)

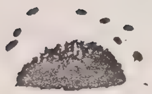
These grow to four (4) feet tall and have bright green foliage, red bark, and small, white flowers. Greenleaf manzanita grows best in sunlight on semi-dry sites.

Service berry
(Amelanchier alnifolia)

Service berry is an erect shrub, four (4) to fifteen (15) feet high, characterized by gray bark on older stems and reddish brown bark on younger stems and branches. Known for profuse white flowers and purple fruit, it grows best on moist to wet sites.

Penstemon
(Penstemon newberryi)

This low shrub, with bright red or crimson flowers, grows nine (9) to eighteen (18) inches tall and does best on semi-moist sites.



Sulphur flower buckwheat
(Eriogonum umbellulatum)

Sulphur flower, characterized by whitish leaves at its base and yellow flowers, grows twelve (12) inches high or more. It does best on gravelly, semi-dry sites.

Squaw carpet
(Ceanothus prostratus)

This spreading ground cover has dark green leaves and blue flowers and grows best on sunny, moderate sites. A slow, low growing cover — approximately four (4) inches — not recommended for foot traffic areas.

Willow
(Salix spp.)

These shrubs, which reach fifteen (15) feet tall, grow best on wet sites but will adapt to semi-moist sites. Consult your local nursery for information on which of the 27 species of willows are common in the Lake Tahoe Basin.

Choosing Trees

The following native trees are excellent choices for revegetation, if planted in the correct environment. When selecting, match requirements to planting site characteristics.

Lodgepole pine
(Pinus murrayana)

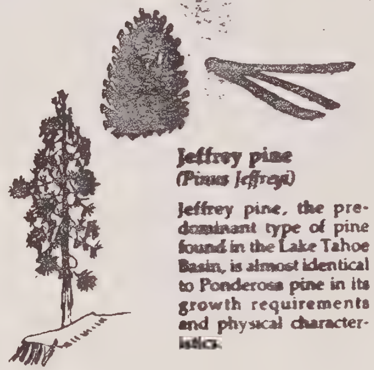
Mature lodgepole pine grows to approximately 75 feet. The slender pine produces cones under two inches long and grows best on moist to semi-moist sites.

Aspen
(Populus tremuloides)

This beautiful deciduous tree with small round leaves does best on moist sites.

Ponderosa pine
(Pinus ponderosa)

Ponderosa pine, a tall — over 200 feet — evergreen tree, does well in semi-dry sites with full sunlight. The bark smells of vanilla.



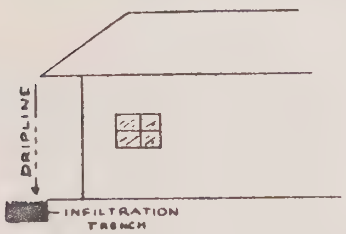
Jeffrey pine
(Pinus Jeffreyi)

Jeffrey pine, the predominant type of pine found in the Lake Tahoe Basin, is almost identical to Ponderosa pine in its growth requirements and physical characteristics.

White fir
(Abies concolor)

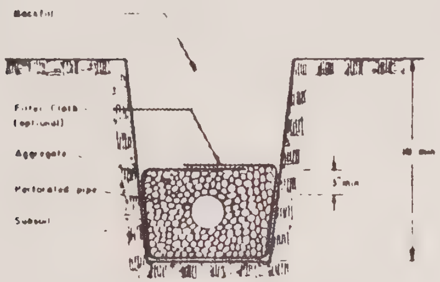
White fir reach 150 feet and grow best on dry to semi-moist sites. White bark characterizes the young trees.

More Permanent Measures



Rock-filled Trench

One method of permanent drainage control is a rock-filled trench. This type of trench is used to infiltrate runoff from impervious surfaces, such as roofs and driveways, which cannot infiltrate runoff naturally. The infiltration trench dimensions are based on the size of the impervious surface and expected storm intensity, depending on location. These trenches have a limited capacity, so give adequate consideration to overflow control.



Sub-surface Drain Trench

If your lot has a high ground water level or intermittent seeps and springs, consider constructing underground gravel trenches to prevent foundation damage. These French drains intercept sub surface water movement and discharge the water to a stable outlet. Obtain professional advice to ensure proper design.

Many of the measures presented here will require design by a qualified engineer. Contact the Soil Conservation Service for assistance.

The final step in soil stabilization is to remove all the construction waste and debris, and revegetate the disturbed site. A separate guide, "A Practical Guide For Planting In The Lake Tahoe Basin" is available from your local Soil Conservation Service.

Construction Reviews And Permits

If you are contemplating any construction activities, grading or excavating, you may need a review and permit from at least one of the governmental jurisdictions in the Basin. To locate the responsible agency, check the list below. (When obtaining your permit first go to the city or county, then to the regional agencies. If your lot is on the Lakefront, however, go directly to the Tahoe Regional Planning Agency).

City of South Tahoe
Carson County
Douglas County
El Dorado County
Placer County
Washoe County

California Tahoe Regional Planning Agency
Tahoe Regional Planning Agency
U.S. Forest Service

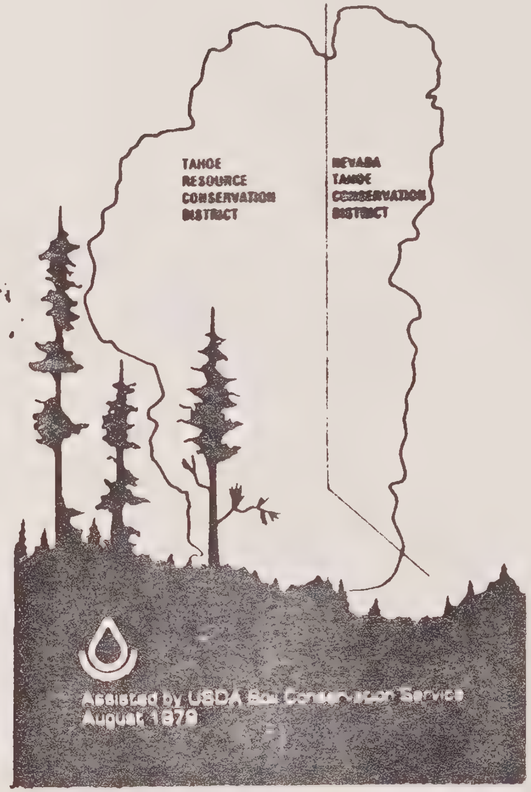
Public Utility Districts
General Improvement Districts

Need Technical Assistance?

To obtain technical assistance, contact the following agencies:

Nevada Tahoe Conservation District
Tahoe Resource Conservation District
Soil Conservation Service, USDA
P.O. Box 10529
3552 Highway 50
So. Lake Tahoe, CA 95731
916/541-1496 or 541-5654

A PRACTICAL GUIDE FOR BUILDING In The LAKE TAHOE BASIN



Controlling Lake Tahoe Basin Erosion

Sediment pollution from soil erosion in the Lake Tahoe Basin seriously threatens the water quality of the lake and its tributaries.

Natural elements, such as wind and water, slowly degrade all lands, but man's activities such as construction, increase the rate of erosion above natural levels.

When man moves vegetation on Basin lands, he exposes the easily erodable soils to wind and water action. Displaced soils wash into streams and drainageways. These waters, now laden with sediment and soil nutrients, eventually enter and pollute Lake Tahoe.

By following this guide, you will help preserve Lake Tahoe's water quality. If you are living in a Stream Environment Zone, you will help reduce damage to the natural water cleansing process.

To control soil erosion and problems caused by building, homeowners may use a combination of structural and vegetative practices that are outlined in this guide.

For further assistance, consult "A Practical Guide For Planting In The Lake Tahoe Basin." Contact the Tahoe Resource Conservation District in California, the Nevada Tahoe Conservation District in Nevada, or the Soil Conservation Service for copies. Offices are located at 3552 Highway 50, South Lake Tahoe.

Fill slopes such as the one shown cause erosion in steep mountain developments. To establish vegetation, grade slopes to 50 percent (two feet horizontal to one foot vertical) or less.

Planning

First, you will need a comprehensive construction plan. The plan should include Stream Environment Zone identification, cut and fill specifications, and proper siting and design. By developing and following a comprehensive plan, you can avoid unnecessary disruption, and subsequent costly and time consuming control measures.

The next step in your building process is to determine if you are in fact in a stream environment zone. A stream environment zone is that area directly surrounding a major stream, minor stream, or drainageway, including a sufficient buffer strip to protect the stream characteristics. It is important for you to check if you are in a stream environment zone because these areas have restrictions placed on them. Also, Tahoe experiences periodic flooding and people have suffered damage to their investments in stream environment zones.

Most of these areas can be identified by the presence of water, certain soils and riparian vegetation. Some areas, however, are not easy to identify because some streams and drainages are intermittent, flowing only part of the year. Regularly flowing streams are identified on the U.S. Geological Survey (USGS) topographic map available at the Tahoe Regional Planning Agency offices, or most sporting good stores. These maps will identify all major and minor streams.

The intermittent streams and drainages, which may be visible only part of the year, can be determined by on-site inspection to locate a drainage channel or other topographic depression, distinctive vegetation (lush green areas, wildflowers, alders, willows, aspen, lodgepole pine), and alluvial soils. Soil maps are available from the U.S.D.A. Soil Conservation Service.

Siting

A carefully planned siting of your structure can alleviate a lot of subsequent problems, such as eroding soils and flooding yards. Consider the following when determining your site:

1. The structure should be at least 50 feet from the mean high water line of the stream.
2. If the land parcel lies partially within and partially outside of the stream environment zone, the structure should be sited outside of the stream zone.
3. If the entire parcel is in the stream environment zone, then try to site the structure in the best manner to do the least harm to the area.

Design

When you are designing a structure in a stream environment zone, allow for water of about a 100-year flood event to pass through unobstructed. To accomplish this, it is best to use a pier or single-span type foundation design. (Piers are similar to stilts. Single spans are bridgelike foundations placed over the stream or drainage.)

Protect trees with proper fencing

Retaining Vegetation

When developing your site plan, it is to your advantage to save as much vegetation as possible. The vegetation will naturally curb erosion, increase the aesthetics and value of your property, and reduce the cost of landscaping your lot in the future. Remember it takes years to replace just one tree.

Before you begin grading and constructing, decide which plants to save. Determining the health, vigor and aesthetic value of the plants will help you make this decision.

During construction, you can protect plants by fencing to prevent undue traffic and by locating trenches away from the vegetation. You also can protect vegetation by placing building materials inside the foundation or on driveways and by not placing fill material over the plants.

Protect trees within 25 feet of a building site by fencing to prevent mechanical injury. Fencing should be located outside of the drip line of the tree's longest branch. Do not nail boards to the trees and do not cut the feeder roots which are inside the drip lines of the trees.

When grading near a tree, be careful not to grade too close or too deep, or you will damage the roots. Also, keep fill material away from tree trunks or you will cut off air circulation to the tree. If you must pave the area near the tree, do so by using permeable asphalt to allow infiltration of water and aeration of the root zone.

If you accidentally damage tree trunks or expose roots, cover them immediately with a tree paint or wound compound to protect the damaged area from insects and disease. If you must remove tree limbs, do so close to the trunk or main branch, and then cover with tree paint. For severe damage, check with a tree surgeon.

Stabilizing Slopes — Cuts & Fills

If your site is going to require grading cuts and fills you will need to determine your slope design and maximum length before you begin work. This will help prevent eroding slopes and resulting problems, such as mud sliding into the yard or loss of vegetation. It will also help avoid costly stabilization techniques, because the slopes will be constructed correctly in the first place.

Note: This information applies only for small jobs, no larger than those found on a normal sized family lot. For larger areas, refer to the more detailed procedure available from your local resource conservation district office.

Determining Slope Shape

The slope should be designed to preserve and blend into the natural contours and undulations of the land, to retain all possible existing vegetation, and to minimize required earth work and scars from cuts and fills. To accomplish this:

— Do not exceed the natural angle of repose or steepness of a two to one (2:1) slope. Slopes will erode when they are too steep.

— Do not place cuts and fills closer than three (3) feet to the property line.

— Set building foundations back from the top of a cut slope a minimum of six (6) feet.

— Do not have the top and bottom of fill slopes closer than ten (10) feet to any adjacent property line.

— Round off the top and toe of the slope, and place a bench at the base of the slope to catch eroding materials.

Determining Maximum Slope Length

The maximum length of a slope is calculated in order to determine how long it can be before the slope starts eroding unnaturally. This also helps determine the spacing between stabilization measures (trenches, berms, etc.)

If your slope steepness is about four to one (4:1), the maximum slope length should not exceed 33 feet. If your slope steepness is about three to one (3:1), the maximum slope length should not exceed 21 feet. If your slope steepness is about two to one (2:1), the maximum slope length should not exceed 18 feet.

See Inside

Grading

Your next step in construction will be grading. Be sure to incorporate the following into your grading plan:

— Make sure that all graded cut and fill slopes are not steeper than two to one.

— Protect all disturbed slopes from erosion by vegetation or gravel lining, jute netting or straw mulching.

— Make provisions to handle runoff generated on the grading site by installing slope drains, chutes, or stone lined ditches.

— Protect cut and fill areas from surface runoff by constructing diversion ditches.

— Avoid construction in high water table areas.

— Do not place fill near streams or channels.

— Make sure that adjoining property is protected from erosion and runoff caused by excavation, filling operations, or drainage water.

— For access roads or driveways, pave or surface with gravel

Note: To reduce the impact of construction activities in stream zones, wait until the soils have dried or at least a week after the disappearance of all surface water from the site before beginning. This will insure a more solid surface which will not gully and erode as heavily when wet.

As you proceed with the actual grading, be sure to:

— Remove rocks, logs and rubbish.

— Stockpile rocks and vegetative matter, such as pine needles, logs and stumps, that can be used later for landscaping and soil stabilization

— Stockpile topsoil to use in finish grading of exposed areas requiring topsoil.

— Control dust on graded areas by sprinkling with water or applying mulches, stone or vegetative cover

— Restrict traffic to pre-determined routes to avoid soil disruption and damage to vegetation.

Controlling Runoff

It is important to keep water contained on the construction site. When a storm or snow melt occurs on disturbed soils, runoff will carry the soils from the site and dump the sediment into adjacent lots, streets, streams, and eventually the lake.

You should implement temporary methods to keep water on the site, to allow it to percolate into the ground and catch sediment. At a later date, plan to install permanent measures. At that time, portions of your temporary methods may be removed.

These measures should also prevent high flow waters from a stream from entering the construction site. The design and installation of these facilities must be conducted with extreme caution to prevent damage to the stream zone.

Sandbag Sediment Barriers

These are similar in use and purpose to straw bale barriers, but are constructed of sandbags. Stack them close together. If stacking over two bags high, anchor with steel rods

Filter Berms

These are gravel or crushed rock berms used to slow down water so that the sediment load can be deposited. The water filters through, leaving the sediment behind. Therefore, do not cover with plastic or other forms of sheeting. These berms should be one and one half (1 1/2) to two (2) feet high, three (3) to five (5) feet wide, with side slopes of three to one (3:1) or flatter, and made out of one half (1/2) to three quarter (3/4) inch course washed gravel or rock

Straw Bale Barriers

Retard water runoff by using straw bales around property lines near storm drains, across minor swales or ditches, or other areas of water drainage. Don't block off large drainages, however. In addition, straw bale barriers will filter out sediment and help percolate water into the ground

Stack bales in an interlocking fashion for strength and tie for longer use. Secure bales to the ground with wood stakes. To prevent water from cutting a channel under the bales, set them in a trench six (6) inches deep. Straw bales decay over time, so either replace or remove them when this occurs

Sediment Debris Basins

You can install sediment debris basins to catch eroding soils. These basins are small depressions with berms or dikes on the lower side. They catch sedimentation and allow eroded material to settle out. To prevent sediment overflow, clean basins periodically. If measures have been taken to permanently stabilize the disturbed area, you may remove the basins. Or the basins can become permanent measures

Stabilizing Soils — Temporarily

To temporarily protect disturbed soil surfaces during construction, use the following measures:

Wood Chip

Prepare wood chips by processing tree trunks and branches in a wood chipper (sizes 1½ x 1½"). Spread on the ground about three (3) inches deep. If you want to plant the area later where the wood chips are laid, you will need a 25 percent increase in fertilizer above what you would normally use to replenish nutrients.

Note: If you are having a tree company remove tree branches or trees, they can chip them for you.

Straw Mulch

This is a cover of clean, weed-free straw put on bare ground to stop erosion, and where seeded, to aid in germination and growth. Grass clippings and pine needles can also be used. The mulch should be used on bare soils and on revegetated sites.

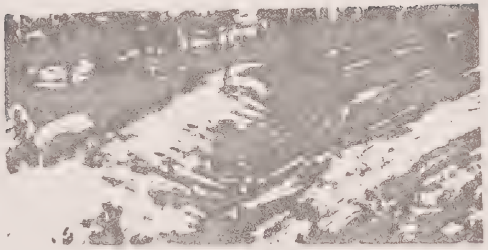
To protect the straw from wind and water damage, generally apply mulch at 50 pounds per 1,000 square feet. Hold straw into place with tackifier or with netting such as jute or plastic. Or, punch the straw into the ground with a shovel or crimping machine.

Be careful not to let straw get into a stream, because often it harms aquatic life.

Crushed Stone and Gravel

Surfaces can be protected with crushed stone or gravel that is about three-quarter (3/4) to one and one-half (1½) inches in diameter. Apply the material uniformly, using about two and one-half (2½) tons per 1,000 square feet. The minimum acceptable surface coverage is 90 percent. If traffic is moving over the area and ruts occur, the area should be graveled again. On steep slopes, terracing may be necessary.

Stabilizing Soils — Permanently



Diversion Dike

This is a ridge of soil constructed at the top of a slope which diverts the flow of water away from the slope face. The diverted flow must be directed somewhere else, preferably to a heavily vegetated area for percolation into the ground, or into a downdrain around the slope face.

The dike should be one and one-half (1½) feet high, two (2) feet wide, two to one (2:1) slope or flatter. If large flows are expected, or if the drainage flows are similar to an intermittent stream, use permanent drainage facilities rather than this dike.

Rock Retaining Wall

This is an attractive method of stabilizing a small over-steepened or unstable slope. If the wall must be over three (3) feet in height, you will need engineering assistance.

To build your wall, excavate a footing trench along the toe of the slope.

Place the largest rocks in the footing trench and backfill the trench. Also, arrange subsequent rock layers so that each rock above the foundation is firmly positioned on the underlying rocks.

To support the wall and have a gradual slope behind it, obtain fill material from the slope and place it behind the rock wall. The slope above the wall should be maintained at two to one (2:1) or less with a slope bottom bench at the toe, sloping at two percent down to the top of the rock wall. Plan to revegetate the stabilized soil as soon as possible after completing the wall.

Gabion

Gabions, wire baskets filled with rock, are very effective for toe slope stabilization on some steep and high slopes. Consult a qualified engineer when using gabions to ensure proper design. Grade the slope above the wall two to one (2:1) or less.

Rock Lined Ditch

Rock lined ditches stabilize the banks and bottoms of a drainage swale or depression. Place cobbles and rocks one and one-half (1½) inches to eight (8) or ten (10) inches or even larger sizes, tightly into the drainage channel. The extent of rock lining required depends on the size of the channel. For channels wider than three (3) feet and or deeper than one and one-half (1½) feet, obtain engineering advice.

Eventually, permanent measures will need to be installed. If the temporary measures are not part of the permanent plan, they should be removed.

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WQ Tech Memo No 49
William F. Dietrich & John A. Davis
Jefferson Associates

WATER QUALITY MANAGEMENT PLAN

CATCH BASIN AND STORM SEWER CLEANING AS SURFACE RUNOFF CONTROL MEASURES

Technical Memorandum No.49

March 14, 1980

A INTRODUCTION

The purpose of this technical memorandum is to examine the effectiveness of cleaning storm sewer system components as surface runoff control measures. Three components were evaluated; catchbasins, inlets and the storm sewers themselves.

Catchbasins and inlets are the structures installed in the gutters of city streets to collect storm runoff and convey it into the storm sewers. The difference between the two is that catchbasins are specifically designed to trap solids in a sump and prevent them from entering the collection system. Inlets often trap some smaller amount of solid material but only inadvertently as a result of design imperfections. Catchbasins predate inlets and were devised to protect combined sewers from excessive deposits of sand and gravel washed from frequently unpaved streets. They are now generally considered to be both unnecessary and the cause of much costly maintenance by public works engineers.

Because all three of the structures evaluated accumulate materials from the surface runoff stream their cleaning could reduce the total pollutant load imposed on the receiving waters. The cost-effectiveness of cleaning as a surface runoff control is explored in this memorandum.

There is a scarcity of information on the subject of this memorandum. The contents of several technical libraries in the Bay Area were searched and all relevant information reviewed. ABAG's 1979 survey of public works practices was a valuable source of information. Data from the

survey questionaire was supplemented by telephone interviews with local public works staff members.

B SUMMARY AND CONCLUSIONS

1. Catchbasins

Catchbasins make both positive and negative contributions to surface runoff pollution. Early on in a storm the flushing of supernatent fluid from basins tends to accentuate the peak or shock load on receiving waters. Subsequently catchbasins reduce the total pollutant load by retaining some pollutant materials in their sump. Because of this trade-off it appears unlikely that the installation of catch basins in new construction could be justified on the basis of water quality benefits.

However, accepting that catchbasins already exist in many parts of the Bay Area, their cleaning appears to offer promise as a cost-effective means of removing pollutant material. A more refined analysis must be undertaken before a decision can be made but on the basis of a preliminary analysis a dollar spent on catchbasin cleaning appears to remove more pollutants than a dollar spent on street-sweeping.

2. Inlets

Little data is available on inlet cleaning. Data that do exist suggest that inlet cleaning is probably less cost-effective than catchbasin cleaning because of the relatively small amount of pollutants removed per cleaning.

3. Storm Sewers

Insufficient data are available to determine the effectiveness of storm sewer cleaning as a surface runoff control measure.

C CATCHBASINS

Most city or county public works departments have a standard catchbasin design which is used throughout their area of responsibility. A typical standard catchbasin design, used in the City of San Francisco is shown in Figure 1. In some cases catchbasins may not be directly connected to the street, but may receive runoff from two or more inlets.

Pollutants enter catchbasins during storms via runoff and during dry periods from wind, traffic and human discard. Stormwater runoff carries dirt (sand, silt and clay), eroded material from vacant lots and streets, debris from construction sites, air pollution fallout, particles dropped by vehicles and animal feces. Dry period loadings consist of litter, leaves, garden clippings and dumped oil and garbage.

1. Pollutants in Catchbasins

Catchbasin Contents

Catchbasin contents vary widely from place to place depending on the nature of land-use in the area in which they are installed. Table 1 presents data on the contents of twelve catchbasins in San Francisco. The San Francisco data is the most detailed available on catchbasin contents nationwide. Biochemical oxygen demand (BOD) of the liquid found in seven catchbasins in Chicago is shown in Table 2.

Catchbasin contents usually consist of a sludge deposit covered by foul liquid. The amount of fluid depends upon many factors including the elapsed time since the most recent precipitation and the evaporation rate.

Because the solids and fluids sit in the catchbasins for extended time intervals between flushing, biological and chemical reactions occur which create septic sludge and liquid. Lager makes the following note:

> The reported BOD concentrations measured in catchbasins are consistently higher than concentrations normally found in running stormwater, frequently by as high as 5:1. This may be accounted for by (1) the dumping or flushing of waste material into basins between storms, (2) the concentrating effect (treatment) of the runoff as it passes through the small detention unit; (3) decomposition of the residual organic sediment over time, and (4) evaporation.

Normalizing the data in Table 1 by casting out the extremes and averaging, the "typical" catchbasin might contain material having the characteristics shown in Table 3.

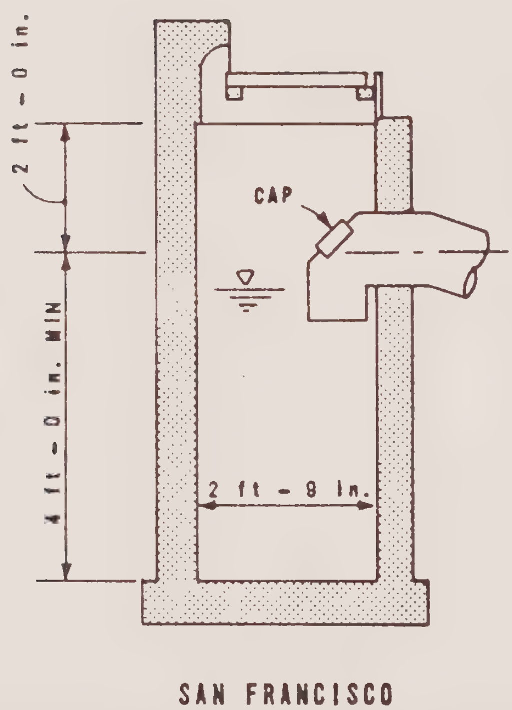


Fig. 1. Typical catchbasin design, San Francisco

Source: Lager, 1977.

Table 1

CATCHBASIN CONTENTS IN SAN FRANCISCO

Catchbasin location	First sampling series, mg/L				Second sampling series, mg/L			
	COD	BOD_5	Total N	Total P	COD	BOD_5	Total N	Total P
Plymouth and Sadowa	3,860	190	10.9	<0.2	8,610	122	2.8	0.3
7th and Hooper	15,000	430	33.2	<0.2	2,570	170	2.0	<0.2
Yosemite	739	11	1.8	<0.2	21,400	120	4.6	<0.2
40th and Moraga	9,060	40	16.1	<0.2	51,000	13[illegible]	12.0	<0.2
Mason and O'Farrell	8,100	130	29.7	<0.2	7,720	85	16.5	<0.2
32nd and Taraval	153	5	0.5	<0.2	708	15	1.4	<0.2
Haight and Ashbury	37,700	1,500	1.4	<0.2	143,000	420	14.6	<0.2
Marina area	701	100	7.0	<0.2	8,600	40	0.5	<0.2
Montgomery Street	6,440	390	18.8	<0.2	8,160	300	3.9	<0.2
Webster and Turk	1,440	44	14.0	<0.2	....	...	....	...
Lower Selby	288	6	1.4	<0.2	....	...	....	...
Upper Mission	5,590	50	12.0	0.2	....	...	....	...

Note: Both sampling series were conducted in winter 1970. All values based on an analysis of total basin contents after complete mixing.

Source: San Francisco City and County, California, Department of Public Works, 1971.

Table 2

BOD CONTENT OF LIQUID IN CHICAGO CATCHBASINS-A SMALL SAMPLE

Number	Zoning	BOD of liquid contents mg/l(ppm)
1	Commercial	225
2	"	150
3	"	35
4	"	160
5	"	60
6	Residential	50
7	"	85

Source: American Public Works Association, 1969, p85.

Table 3

"TYPICAL" POLLUTANT CONCENTRATIONS IN CATCHBASINS

	Entire contents (solids and liquids) San Francisco
COD	6,800 mg/L
BOD_5	170 mg/L
Total Nitrogen	8.3 mg/L
Total Phosphorus	$<$0.2 mg/L

Tabulated from data in Table 1.

Behavior of Catchbasin Contents during Storms

During a storm, two phenomena occur which determine the total pollutant load of water leaving a catchbasin. Stormwater stirs the catchbasin contents and flushes out the supernatant liquid and a portion of the settled solids. Simultaneously, dense particulate solids carried by the influent settle out and remain in the catchbasin.

Flushing of the supernatant liquid: In 1969, the American Public Works Association conducted experiments in Chicago to determine the degree of flushing of supernatant liquid using sodium chloride solution. In the tests, a volume of clean water equal to the catchbasin volume was flushed into the basin. This flushed out about half the salt solution in the basin. Another equal volume of clean water was added, flushing out half of the remaining salt solution. A third added volume of water produced the same result. The net result was that seven-eighths of the original salt solution was flushed out.

In the Chicago test area, 0.3 inches of rain would wash out 94 percent of the original fluid in a catchbasin. Thus almost all the pollutants in the fluid would be released. The proportion of liquid flushed out depends upon catchment area, rainfall intensity and duration, catchbasin size and hydraulic factors.

Flushing of the settled solids: Sartor and Boyd (1972) ran tests on "dirty" catchbasins to see how much of the contents would be removed by various flowrates of clean city water. The initial discharge was "very dirty, composed primarily of this supernatant water, some of the floating matter, plus particulate matter suspended by the turbulence flow." (p131). After several minutes the water became relatively clear but contained particulates. The discharge continued to carry particulates for the hour-long testing time. Measurements of the remaining contents showed a very slight reduction in solids of about one percent as shown in Table 4.

Sedimentation of influent solids: To evaluate the sedimentation of particulates in catchbasin sumps Sartor and Boyd washed a graded simulant into a clean catchbasin in San Francisco. Figure 2 shows that the structure effectively retained large solids but not small ones. Lager tested the performance of a model catchbasin of standard design. His model captured most solids with a particle size greater than 0.25mm. Because most of the pollutant materials from street surfaces are associated with the smaller particles they are not retained by catchbasins. Based on Sartor and Boyd's data the following proportions of street surface contaminants are associated with particles smaller than 0.25mm, 57% BOD, 80% COD, 77% nitrates, 60% volatiles, 92% phosphates and 43% total solids.

Lager calculated the probable percentages of retained materials for an individual storm of 5 hour duration, and 0.14 in/hr intensity assuming a sediment buildup of fifty percent or less. The results are shown in Table 5. Under very high inflows (e.g. 56.6 l/s, 2.0 cfs), Lager's model catchbasin was ineffective in removing even coarse solids

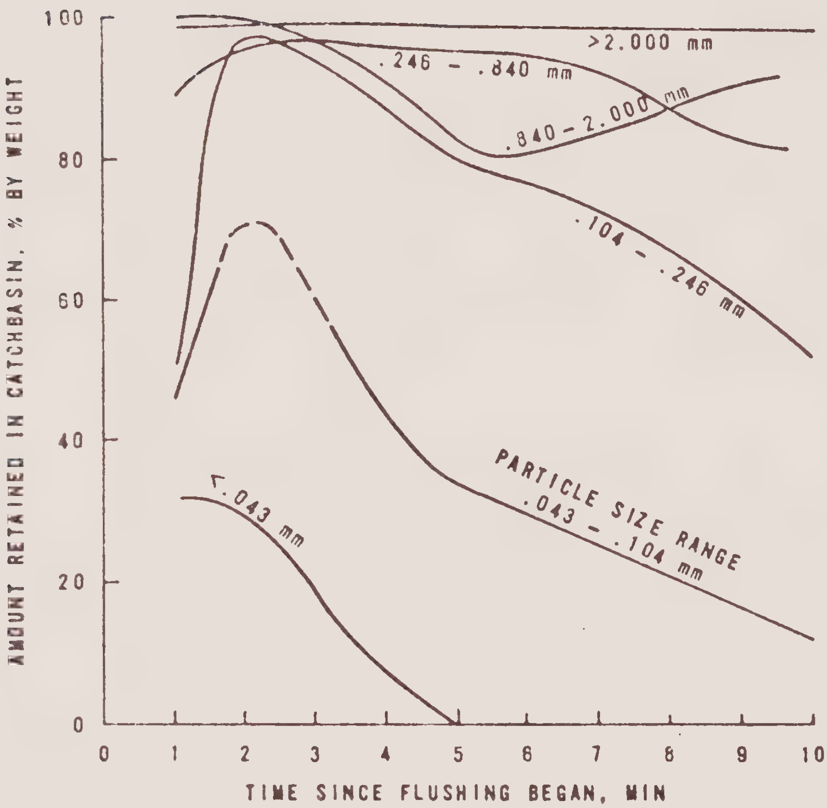
Table 4

SOLIDS FLUSHED FROM "DIRTY CATCHBASINS" BY CLEAN WATER

Catchbasin	Catchment area ha (acres)	Inflow rate, L/s (cfs)	Weight of solids in basin at outset, kg (lb)	Solids flushed from basin during storm	
				Weight, kg (lb)	Fraction, %
A	0.39 (0.96)	7.9 (0.28)	929 (2,047)	13.4 (29.6)	1.2
B	0.23 (0.57)	7.9 (0.28)	1,162 (2,559)	13.6 (30.0)	1.1
C	0.10 (0.25)	6.5 (0.23)	1,580 (3,481)	9.8 (21.6)	0.6

Source: Sartor and Boyd, 1972.

Figure 2. PARTICLES RETAINED BY CATCHBASINS DURING FLUSHING



Source: Sartor & Boyd, 1972.

Table 5

PERCENTAGE OF MATERIAL RETAINED IN CATCHBASIN FOR INDIVIDUAL STORM

Constituent	Probable % retained	
	Worst	Best
Total solids	42.1	75.0
Volatile solids	15.2	25.5
BOD_5	15.5	26.6
COD	7.5	14.1
Kjeldahl nitrogen	14.6	27.4
Nitrates	9.5	17.1
Phosphates	2.3	6.0
Total heavy metals	37.4	64.4
Total pesticides	13.6	29.7

Source: Lager, 1977.

when the accumulated sediment exceeded 50 to 60 percent of the storage basin depth. Lager makes a special point that his model catchbasin is most effective in retaining solids when the sump is no more than about 50 percent full. Excessive sediment levels reduce retention time and consequently the effectiveness of sedimentation.

2. Cleaning Practices

Catchbasins are cleaned manually or by a variety of mechanical methods (See Appendix). In most cases solids are removed from the basins and liquids flushed into or otherwise returned to the sewer. Sometimes high pressure hoses are used to flush both solids and liquids into the sewer.

According to Lager's study, American cities usually clean catchbasin once or twice annually. In the West, an annual cleaning often takes place in the fall before the rainy season, to reduce the number of blockages and subsequent street floodings during storms. Public works departments place the highest priority on cleaning out basins that are blocked.

Table 6 shows the results of a local survey of catchbasin cleaning methods, equipment, personnel and frequency.

3. Cleaning Costs

Information from the ABAG and telephone survey often proved incomplete. More importantly, total annual catchbasin cleaning costs often omitted amortized equipment cost (or total program costs included a different mix of factors for each jurisdiction). Frequently, the costs for catchbasin cleaning were not separated from the costs of other programs (sewer cleaning, inlet cleaning). For example, a public works department may have a certain number of workers to perform many tasks and the time spent solely on catchbasin cleaning is not recorded.

The reported annual program cost divided by the number of cleanings per year gives unit costs of $10 to $35 per catchbasin. The average value is $21 per catchbasin.

4. Implications for Water Quality Management

The effect of catchbasins in an urban storm sewer system is to change the shape and size of the pollutant hydrograph. It is difficult to quantify the effects, however. Data from a variety of sources allows a qualitative picture to be developed within a rather approximate numerical framework.

Figure 3 shows a hypothetical pollutant hydrograph for an area of urban development draining to a single catchbasin. If it is assumed that at the start of a storm a typical catchbasin holds some accumulated solids and a considerable volume of supernatant liquid, then it is apparent from data previously presented that the supernatant liquid will be flushed into the sewer early in the storm. Because the supernatant

Table 6

LOCAL SURVEY DATA ON CATCHBASIN CLEANING

County City	Number of Catchbasins by Land Use Commercial	Industrial	Resid.	Total	Annual Cleaning Frequency	Total Cleanings	Method	Equipment	Personnel
Alameda									
Albany				10	2	20	manual		
Berkeley				1900	1	1900	vacuum		
Contra Costa									
Concord				4000±			vacuum		3 men-3½ months
Lafayette				300	.33	100			
Richmond	20	20	100	140	1		manual, flush, vac.		
Marin									
Belvedere				200	1		flushing		
Fairfax	20		200	220	1	220			
Novato	50		1450	1500	1	1500			
Napa									
Napa				500	as needed				
San Mateo									
Belmont	100	50	1161	1311	1				
Brisbane				115	2	230	manual		
Daly City	65		1244	1309	1	1309	manual- vacuum		
Redwood City				2,700±	2	5000±	manual		
San Carlos				1,700±	1	1700±	vacuum	Vactor	
San Mateo				2,000±	1	2000±	(now) vacuum.		1 worker-yr
Solano									
Vallejo Flood Control Dist				100±					
Sonoma									
Cloverdale	19		41	60	1	60	manual flushing		
Santa Rosa				2,700	.5	1350			
San Francisco				24,000		8-10,000	Vacuum	Vacujet	

Table 6 (Cont'd.)

LOCAL SURVEY DATA ON CATCHBASIN CLEANING

County / City	Labor Cost	Total Cost	Total Cost/No. of cleanings = Cost/cleaning	Labor cost per cleaning	estimated Amount removed cu.yd	Total cost / Amt. removed = Cost/unit	Amt removed per C-B
Alameda							
Albany							
Berkeley							
Contra Costa							
Concord	$27/hr						
Lafayette							
Richmond					20 cu yd		
Marin							
Belvedere							
Fairfax	4,790	$5,190	$24/C-B	$22/C-B			
Novato		$75,000 includes inlets	($50/C-B reported)				
Napa							
Napa							
San Mateo							
Belmont					350 cu yd		
Brisbane							
Daly City	$24,400	$42,400	$32/C-B	$19/C-B			
Redwood City					400 cu yd		
San Carlos	$7,400			$4/C-B inlets?	320 cu yd		
San Mateo							
Solano							
Vallejo Flood Control Dist		$3,500	$35/C-B		50 cu yd	$70/cu yd	0.5 cu yd/C-B
Sonoma							
Cloverdale							
Santa Rosa	8,000	15,000	$11/C-B	$6/C-B			
San Francisco		122,000	$15/C-B				

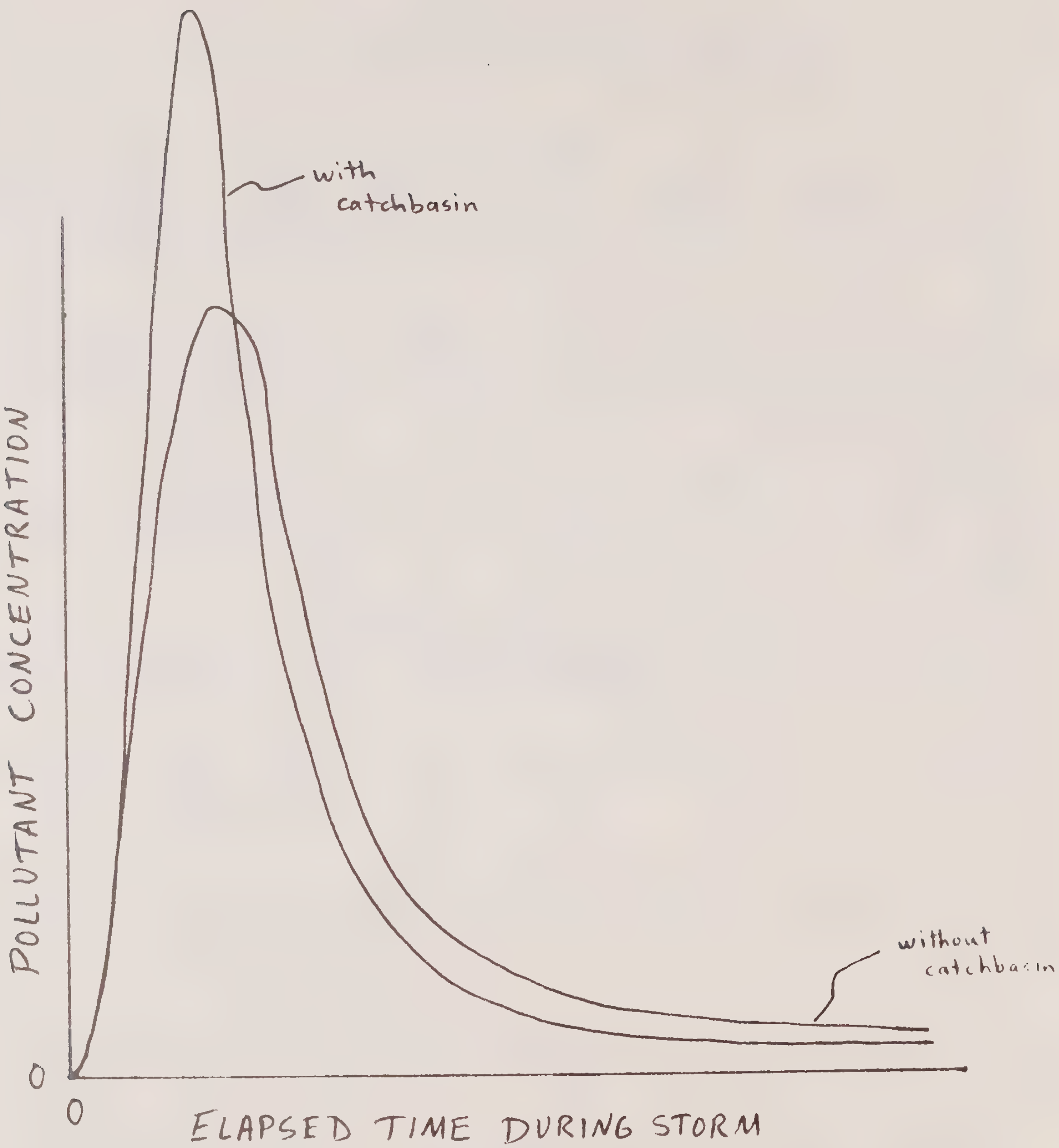


Figure 3. HYPOTHETICAL POLLUTANT HYDROGRAPH--
THE EFFECT OF A CATCHBASIN

contains higher levels of pollutants than typical urban runoff its discharge to the sewer will tend to accentuate the early peak in the pollutant hydrograph. As the storm progresses and the polluted supernatent is flushed out, the effects of retention in the catchbasin of pollutant materials associated with solids becomes noticeable. The tail of the pollutant hydrograph shows pollutant concentrations below those that might be expected if no catchbasin existed. If the catchbasin is cleaned after the storm the pollutant material associated with solids removed will be permanently lost to the receiving waters.

Flushing of supernatant

For a typical retained volume of 545L (144gal) (Lager, 1970) with an average BOD_5 load of 110mg/L (APWA, 1969), the total BOD_5 in the liquid equals 60g. Since a rainfall of as little as 0.05cm/h (0.02in/h) for four hours will displace approximately 95 to 98 percent of the liquid in a basin with a typical catchment area and runoff coefficient (Lager, 1970,p5), about 58g of BOD will escape. Multiplied by an estimated number of 40,000 catchbasins in the Bay Area this equals 2320kg of BOD in a single storm. This shock pollution load is equivalent to the treated sewage from 30,000 people during one day.

Solids Retention

As noted previously most of the pollutants carried by stormwater pass through catchbasins. Some of the denser solids settle out. Catchbasins are more effective in retaining solids when the volume of sediment in the sump is less than half of the sump capacity.

Table 7 is an estimate of the mass of pollutants removed in Bay Area catchbasins during a moderate storm (0.14in/hr for 5 hours). Data on availability of street surface contaminants per catchbasin is from Sartor and Boyd. Pollutant retention rates are assumed to be an average of Lager's "best" and "worst" cases shown in Table 5. The values shown in the table may be higher than those actually experienced because Lager assumes that no catchbasin is ever more than half full. This is probably not the case as some agencies report that catchbasins are full after the first storm of the season.

Effect of Cleaning Frequency

Lager attempted to estimate the effect of cleaning frequency on pollutant removal. Assuming a catchbasin volume of 1.7 cubic yards, cleaning when sump is 50 percent full, annual precipitation of 35.1 inches occuring in 50 storm events and taking only street surface contaminants into account Lager made the estimates shown in Table 8.

5. Cost-Effectiveness

In order to determine whether funds invested in catchbasin cleaning are a cost-effective surface runoff control measure it is necessary to determine the cost per unit pollutant removed and compare the results with similar data for other control measures. Ideally this comparison

Table 7

POLLUTANT REMOVAL IN CATCHBASINS DURING A SINGLE MODERATE STORM

Characteristic	Available street Pollutants kg/0.16km	Ave. percentage of material retained in effective catchbasin sump	Ave. kg material retained/catchbasin	Amount retained by 40,000 Bay Area basins (kg)
Total Solids	63.2	58.6	37.0	1.48×10^6
BOD_5	.61	21.1	.13	5,200
COD	4.3	10.8	.46	18,400
Volatile Solids	4.5	20.4	.92	36,800
Kjeldahl Nitrogen	0.099	21	.021	840
Nitrates	.0042	13.3	5.6×10^{-4}	22.4
Phosphates	.048	4.2	.0020	80
Total Heavy Metals	.074	50.9	.038	1,520
Total Pesticides	5.6×10^{-5}	21.7	1.2×10^{-5}	0.48

Estimation method explained on page 17.

Table 8

PERCENTAGE OF TOTAL AMOUNT OF MATERIAL ENTERING CATCH-BASIN REMOVED AS A FUNCTION OF THE CLEANING FREQUENCY

	Cleaning frequency, times/yr				
Constituent	0.5	1.0	2.0	3.0	4.0
Total solids	19.6	39.1	75.0	75.0	75.0
Volatile solids	6.6	13.3	25.5	25.5	25.5
BOD_5	6.9	13.9	26.6	26.6	26.6
COD	3.7	7.4	14.1	14.1	14.1
Kjeldahl nitrogen	7.1	14.3	27.4	27.4	27.4
Nitrates	4.4	8.9	17.1	17.1	17.1
Phosphates	1.6	3.1	6.0	6.0	6.0
Total heavy metals	16.8	33.6	64.4	64.4	64.4
Total pesticides	7.7	15.5	29.7	29.7	29.7

Source: Lager, 1977, p84.

should be made on the basis of total pollution potential removed per dollar invested in each control measure. Although this may be possible it cannot be done within the schedule of the analysis. As a guide a comparison can be made on the basis of total mass of pollutants removed.

If we assume that catchbasins are not cleaned until they are at least half full then a typical cleaning will remove 2500 to 5000 lbs of solids. Catchbasin cleaning costs average around $20 per basin and so 125 to 250 lbs of solids can be removed for each dollar invested. Earlier work by ABAG (Technical memorandum 38) indicates that street-sweeping under the best conditions will remove 37 lbs of solids per dollar invested. Under more typical conditions 10 to 20 lbs of solids per dollar invested can be expected.

It appears that on the basis of mass removed catchbasin cleaning is a better investment that street-sweeping as a surface runoff control measure. This result must be treated with caution, however. Because solids removed from catchbasins probably contain a smaller proportion of fine particles than do solids gathered by street sweepers they may have a lower potential for polluting receiving waters.

Another factor stems from the fact that both street-sweeping and catchbasin cleaning are conducted for reasons other than the accrual of water quality benefits. Thus the comparison of the cost-effectiveness of the two control measures should be on the basis of cost per pollutant removed for that next increment of street-sweeping or catchbasin cleaning effort over and above the level already needed for other reasons.

D Inlets

Inlets are structures installed in the gutters of city streets to collect storm runoff. Unlike catchbasins they do not have a reservoir or sump to collect solids or liquids. Depending on the details of their design they do accumulate some debris.

1. Pollutants in Inlets

The pollutants which flow into inlets during rains are the same as those flowing into catchbasins. Inlets also receive discarded and dumped wastes like basins. Although the pollutant sources are the same, inlets do not retain liquids (unless blocked) and probably do not retain the same kinds of solids that catchbasins do. The only available data on inlet contents are from Oakland, California. Workers cleaned and analyzed the contents of 20 inlets. The dry weight of material removed ranged from 13 to 163 pounds, with an average of 57 pounds. Pollutant concentrations are shown in Table 9. An average load of 26kg (57 lbs.) has approximately 4kg COD, 35g total phosphorus, 28g lead, and 8g total Kjeldahl nitrogen.

The processes associated with the accumulation and washout of sediments in inlets have not been studied. Therefore, the amount of solids which inlets may remove from runoff is unknown.

Inlet design is a factor in how much is retained. Some inlets have flat bottoms; others have bottoms which slope down to the outlet pipe. Those with flat bottoms collect more debris.

2. Cleaning Practices

Inlets are cleaned manually or using a vacuum truck (See Appendix). Information regarding current public works practices in Alameda County is shown in Table 10. Crews usually clean inlets once per year, in fall, to prevent blockages during winter storms. Plugged inlets receive attention as needed.

3. Cleaning Costs

For those cities in Table 10 that supplied sufficient data, the cost per cleaning is calculated. The results vary from about $4.00 to about $17.00. There is no clear correlation between cleaning method and cost.

4. Implications for Water Quality Management

Although an inlet retains much less material than a catchbasin, there are probably more inlets than catchbasins in the Bay Area. Unfortunately, the total amount of material held in inlets cannot be estimated, because their number is unknown. Since there is also no data on sedimentation processes in inlets, the effectiveness of inlet cleaning in abating runoff pollution cannot be evaluated.

TABLE 9

CHEMICAL ANALYSIS OF INLET CONTENTS, CITY OF OAKLAND, 1979
ELMHURST CREEK STUDY AREA

Sieve Size	Percent Sample	COD Conc mg/g	COD Weighted Conc mg/g	TKN Conc mg/g	TKN Weighted Conc mg/g	TOT. PHOS. Conc mg/g	TOT. PHOS. Weighted Conc mg/g	LEAD Conc mg/g	LEAD Weighted Conc mg/g
1/4"	17.5	46	8	0.355	.062	0.450	0.0788	0.240	.0420
#10	35.4	164	58	0.247	.087	1.540	0.5452	1.250	.4425
#20	17.0	244	42	0.342	.058	1.620	0.2754	1.300	.2210
#30	5.8	327	19	0.508	.039	1.630	0.0945	1.400	.0812
#60	13.0	134	17	0.327	.043	1.380	0.1794	1.200	.1560
#140	7.6	108	8	0.448	.034	1.630	0.1239	1.200	.0912
#325	2.7	96	3	0.117	.003	1.400	0.0378	1.300	.0351
Pan	0.4	--	0	--	--	0.500	0.0020	--	--
TOTALS	99.4		155		.317		1.337		1.0690
Adjusted weighted concentration (mg/g)			156		.319		1.345		1.075

SOURCE: Shawley, 1980, p. 3-17.

Table 10

ALAMEDA COUNTY SURVEY DATA--STORM SEWER AND INLET CLEANING

AGENCY	EXTENT OF PRACTICE: INLETS	EXTENT OF PRACTICE: OPEN CHANNELS	EXTENT OF PRACTICE: CLOSED CONDUITS	EQUIPMENT: INLETS: METHOD OF CLEANING	EQUIPMENT: INLETS: TYPE EQUIPMENT	EQUIPMENT: INLETS: NO. IN USE	EQUIPMENT: OPEN CHANNELS: METHOD OF CLEANING	EQUIPMENT: OPEN CHANNELS: TYPE EQUIPMENT	EQUIPMENT: OPEN CHANNELS: NO. IN USE	EQUIPMENT: CLOSED CONDUITS: METHOD OF CLEANING	EQUIPMENT: CLOSED CONDUITS: TYPE EQUIPMENT	EQUIPMENT: CLOSED CONDUITS: NO. IN USE
ALAMEDA	*	**	6 of the total 50 miles (includes culverts) cleaned about once/year	Manual	shovels & buckets		Manual & backhoe	Backhoe, trucks, buckets, shovels		Jet sewer flusher & occasionally a drag bucket		
ALBANY	*		**	Hand Methods	shovels & buckets							
BERKELEY	No. of inlets & no. cleaned are unknown but they're cleaned about once/year	Length of channels & conduits and length cleaned are unknown but they're cleaned about once/year.			jet	1	by hand			by hand		
EMERYVILLE				Manual	hand tools	As req'd	Manual	hand tools	As req'd	Manual	hand tools	As req'd
FREMONT	2900± of the 4600± inlets are cleaned about once/yr	10 of the 15 miles of roadside ditches cleaned about once/yr.	Cannot be determined at this time	Suction & manual	Elgin Whirlwind; hand shovel & bucket	1 rental unit	Backhoe	Case D580	1	N/A		
HAYWARD	Total no. of inlets unknown but they're cleaned at least once/year	All channel (1 mile) is in residential area & cleaned annually	Length of conduit unknown— cleaned as needed	by hand	hand clams	?	Mechanical	Truck crane, clam, tractor	?	Mechanical	Bucket machines, rodding, flushing	?
LIVERMORE		1-2 miles of the 3 miles of channel (all in residential area) cleaned annually ?	3 miles of the 60 miles of conduit (all in residential area) cleaned annually	by hand			Mechanical	Tractor/loader	1	Mechanical	High pressure sewer cleaner	1
NEWARK	All 970 inlets cleaned as needed (1-2 times/yr. ave.)		50 miles of conduit cleaned as needed (very minimal)	Manually	Vacuum							
OAKLAND	4486 of the 9272 inlets are cleaned *	channel lengths unknown **	296.9 miles of conduit. ***	Vacuum & by hand	Vacuum, 2 CY dump	1 Vac., 4 crews	Hand crew	8 C.Y. or 4 C.Y. trucks	4 crews	Hand crew & flushing	Water meter, 2 C.Y. truck	4 crews
PIEDMONT	Unknown no. of inlets in Com. & Res. areas all cleaned annually ?	1/4 of the 3 miles in residential area cleaned annually?	unknown lengths in Com. & Res. areas cleaned as req'd.	by hand			by hand			Rodding	O'Brien	1
PLEASANTON				by hand			by hand +	backhoe, dump truck				
SAN LEANDRO	*	**	***		by hand & shovel							
UNION CITY	All 1300 inlets cleaned about once/year		Approx. half of the 3 miles of conduit cleaned about once/year	Vacuum truck	hand tools, vacuum unit	1 *	Weeding & grading	Grader, Loader, Truck, etc.	1 each	jet rodder	Flushing truck	1 *
COUNTY ROADS	2600± of the 3000± inlets cleaned about once/year			Manual, Mechanical	hand tools; Vacall	1						
FLOOD CONTROL	cleaned about once/year	292 miles of channel cleaned about once every 2 years	0.3 of the 153.8 miles of conduit cleaned annually ?		Vacall		Manual; Mechanical	hand tools; Loader		cable & bucket	bucket machine	1

Table 10 (Cont'd.)

ALAMEDA COUNTY SURVEY DATA--STORM SEWER AND INLET CLEANING

AGENCY	PERSONNEL				COST												
					F.Y. 1977/78			F.Y. 1978/79			INCLUDES						
	NO. CLEANING CBs & INLETS	NO. CLEANING STORM DRAINS	TRAINING PROGRAM	STD. OPERATING PROCEDURE	INLETS	OPEN CHANNELS	CLOSED CONDUITS	INLETS	OPEN CHANNELS	CLOSED CONDUITS	CAPITAL EXPENDITURE	SALARIES	MATERIALS	OPERATION & MAINT.	ADMINISTRATION	EQUIPMENT DEP'N	OTHER
ALAMEDA	4 (when doing it)	4 ([illegible] crew)	No	No		$6,849		xxx	$9,841	xxx	No	Yes	Yes	No	Yes	Yes	OH
ALBANY	less than 1	0	No	Yes	$7,200		$500	$6,500 ($5,300 for 79/80 budget)		$500 ($500 for 79/80 budget)	No	Yes	Yes	Yes	No	Yes	xxx
BERKELEY	6	5	yes	yes	←	Total $57,825	→	←	Total $28,349	→	No	Yes	No		No	No	
EMERYVILLE	3	3	No	Yes	$1,000			$1,000			yes	Yes	Yes	Yes	Yes		
FREMONT	2	4	No	No	$9,892	Not available	N/A	$11,560	Not available	N/A	Not available	No	No	No	No	No	Only equipment rental
HAYWARD	8-30	4	yes	yes													
LIVERMORE	1/4	1/4	No	No													
NEWARK	0.6	0.1	No	Yes	$18,000		$1,000	$20,000		$2,000	No	Yes	Yes	Yes	Yes	No	OH
OAKLAND	5 man-years	5 man-years	Yes	Yes	$43,418	$42,405	$123,130	$49,287 ($55,607 for 79/80)	$68,580 ($53,460 for 79/80)	$141,414 ($150,000 for 79/80)	No	Yes	Yes	No		Yes	
PIEDMONT	3	3	No	As needed	$500	$500	$10,000	$500	$500	$10,000	No	Yes	Yes	Yes	No	No	
PLEASANTON	2 part-time			Yes	←	$20,777	→	←	$11,310	→	None	Yes	Yes	Yes	Yes	No	
SAN LEANDRO	9	some 9	Yes	Yes	$16,443			$18,000				Yes	Yes	Yes	Yes		Equipment
UNION CITY	2 est.	3 est.	Yes	Yes	←	$15,000+	→	←	$17,766	→	Yes	Yes	Yes	Yes	Yes	Yes	
COUNTY ROADS	4	0	No	Yes	$21,490			$15,200			No	Yes	Yes	Yes	No		
FLOOD CONTROL		47±	Yes *	Yes **		$2,200,000	$90,000±		$2,400,000	$80,000	No	Yes	Yes	Yes	Yes	Yes	

Table 10 (Cont'd.)

ALAMEDA COUNTY SURVEY DATA--STORM SEWER AND INLET CLEANING

AGENCY	MISCELLANEOUS: SEASONAL VARIATIONS	MISCELLANEOUS: CONTROLS OR PROGRAMS RESTRICTING DISCHARGES INTO STORM DRAINS	SOLIDS COLLECTED: INLETS	SOLIDS COLLECTED: OPEN CHANNELS	SOLIDS COLLECTED: CLOSED CONDUITS	CONTENTS ANALYZED?	WHAT'S THE COMPOSITION?	Program Cost/System length $/mi F.Y. 78-79: Closed	Program Cost/System length $/mi F.Y. 78-79: Open
ALAMEDA	Try to clean in Fall before rain.	Not a problem	Estimate 50 Tons total						$1950/mi
ALBANY	Prior to rainy season	No				No		$200/mi	
BERKELEY	None	Prohibit discharge of any toxic substance into storm drains	Unknown			Not to our knowledge			
EMERYVILLE	Annual inspection of inlets & CBs in summer					Yes	mixed		
FREMONT	*	Vehicle code. Provisions of City Ordinance re encroachment permits	500 C.Y.	N/A	0	only visually	**		
HAYWARD	*	**				Yes	***		
LIVERMORE		None							
NEWARK	Fall/Winter operation primarily							$40/mi	
OAKLAND	None	ordinance prohibits discharge or dumping	1,965 C.Y.	500 C.Y.	~~[illegible]~~ 600 C.Y.		Unknown	$550/mi F.Y. 79-80	
PIEDMONT	Heavy in late Fall due to leaves	City ord.					All things (unknown)		$2000/mi (actual distance)
PLEASANTON	cleaned yearly in Sept., Oct. & Nov.	None				No			
SAN LEANDRO		****							
UNION CITY		***	325 Tons	100 Tons		No			
COUNTY ROADS		None							
FLOOD CONTROL	***	****						$1739/mi	—

Table 10 (Cont'd.)

ALAMEDA COUNTY SURVEY DATA--STORM SEWER AND INLET CLEANING

AGENCY	COMMENTS
ALAMEDA	* There are approx. 81,000 LF of culvert w/1800 openings. About 40% of the openings are cleaned once a year on the average ** 4.78 miles of open channel: none in Commercial area; of the 1.94 miles in Industrial area, 0.7 miles are cleaned annually; all 2.1 miles in residential area cleaned twice/year; of the 1.94 miles in the recreational area, 0.5 mile cleaned annually *** $11,168 for inlets, conduits & catch basins
ALBANY	* 300± inlets total (includes cross-street drains): All 50± in commercial area and all 10± in industrial area cleaned twice/year; of the 240± in the residential area, 120 are cleaned annually. ** The 1/2 mile of closed conduit in the commercial area and the 8 miles in the residential area are cleaned as needed *** CETA labor 77/78 only.
BERKELEY	
EMERYVILLE	
FREMONT	* Inlets checked & cleaned if needed in Sept., Oct., and Nov. Cleaned the rest of the year only on complaint calls ** Concrete, motor oil, grass, leaves, newspaper, sand, garbage, tires
HAYWARD	* Abnormal heavy rains increase maintenance from debris from hill area. SWI grates w/ perpendicular cross bars over parallel bars increase maintenance during rains. ** Ordinances, personal contact and follow-up with violators *** Timber, cans, muck, concrete, bricks, dead cats, fish, boxes, glass, wet garbage, bundles of newsprint, sand, tires, etc.
LIVERMORE	
NEWARK	
OAKLAND	* 500 inlets on major arterials cleaned 4 times/yr. 500± more are cleaned once/yr on complaint basis. 1900 more are cleaned in residential areas based on visual inspection. During inclement weather, inlets are unplugged whenever draining inadequately. No separation made for land use ** Major channels maintained by ACFCD. Minor channels cleared of detrimental growth as needed. Some cleaning done during rains. *** Inspected when inlets cleaned & cleaned as req'd. Cleaned when sluggish during rains. Plugged lines rechecked & cleaned as req'd
PIEDMONT	
PLEASANTON	
SAN LEANDRO	* All 1250 inlets (120 in Commercial area, 230 in Industrial area, 900 in Residential area) cleaned twice/year ** Total channel length is 0.7 miles (0.5 in Industrial area & 0.2 in Residential area). No other data available. *** 3.0 miles of conduit in Commercial area, 9.5 in Industrial area, 29.0 in Residential area. No other data available **** Local ordinance and Uniform Wastewater Discharge Regulations.
UNION CITY	* Rent from County ** Seasonal *** Letters sent to known violators, news releases in local newspaper and news releases in City newsletter.
COUNTY ROADS	
FLOOD CONTROL	* On the job ** unwritten *** General clearing Spring to Fall; includes cutting encroaching growth, larger debris, metal trash & cans, etc. Major debris cleared at collection points during winter flows. Most silt removed in summer. **** Flood Control permit ordinance not very effective — requires enforcement or much persuasion.

5. Cost Effectiveness

Assuming an average load of 57 pounds, inlet cleaning removes between 3 to 14 pounds of total solids per dollar expended. This is less cost-effective than catchbasin-cleaning (as discussed in catch-basin cleaning cost-effectiveness). Cost-effectiveness for removing specific pollutants is correspondingly lower also.

E STORM SEWERS

Storm sewers are closed conduits which convey storm waters from catchbasins and inlets in city streets to natural channels or other water bodies.

1. Pollutants in Storm Sewers

Modern storm sewers are designed and constructed to be self-scouring. Slopes and hydraulic characteristics are aimed at achieving self-cleaning flows of 3cfs or greater. Stormwater tends to carry most solids within the flow and push gravel and large particulates along the pipe bottom to the outfall. In sections where flows slow down (bends, junctions) and in small diameter conduits, residuals do accumulate and occasionally clog pipes.

A search of technical literature revealed no data on the accumulation of pollutants in storm sewers. It would appear, however, that, because storm sewers are specifically designed to avoid sedimentation, only the largest and densest materials will be retained in the sewer. Because most street surface contaminants are associated with fine particles it seems unlikely that large amounts will be retained in the sewers.

2. Cleaning Practices

Storm sewers are cleaned manually or by a variety of mechanical methods (See Appendix). In most cases accumulated materials are removed from the sewer. Some types of equipment simply dislodge accumulated material and flush it down the sewer.

Most storm sewers do not require cleaning. In order to find pipes with sediment buildup, public works departments set up inspection schedules. Often, pipes are inspected once per year. In trouble spots, inspections may be more frequent. Cleanings are performed as needed.

In some jurisdictions, a regular cleaning schedule is maintained. Certain lines are cleaned once per year, usually in autumn before the rainy season according to survey results.

Tables 10 and 11 display information related to existing storm water collection systems cleaning programs. Alameda County Flood Control District officials provided Table 10. Table 11 is a result of ABAG and telephone surveys.

3. Cleaning Costs

Local costs for storm sewer cleaning are shown in Table 11. Unfortunately few municipalities maintain records of the actual mileage of sewers cleaned and thus costs per mile cleaned are not available. As a very rough guide cleaning costs were divided by total system miles.

Table 11. SURVEY RESULTS--STORM WATER COLLECTION SYSTEM CLEANING

County / City	Number of miles: Closed Conduit	Number of miles: Open Channel	Number of Miles (Proportion) Cleaned: Closed	Number of Miles (Proportion) Cleaned: Open	Annual Cleaning Frequency: Closed	Annual Cleaning Frequency: Open	Cleaning Method: Closed	Cleaning Method: Open	Equipment: Closed	Equipment: Open
Contra Costa										
Concord		30						manual		
Richmond	80	4					manual-rod			Backhoe
Walnut Creek							Vacuum		VacAll	Backhoe
Marin										
Corte Madera	?						flushing			
Napa							flushing router			
Napa	75-100									
San Mateo										
Belmont	5	1					flushing			
San Mateo	153	20	38 (25%)	20 (100%)			clamshell jet			
Santa Clara										
San Jose	1,010						manual vacuum bucket		Vactor	
Solano										
Fairfield	14.9	10.0					vacuum	mech.	VacAll	grader bulldozer
Vallejo Sanit. & Flood Control Dist.	150									
Sonoma										
Petaluma							manual	clamshell		
Rohnert Park							bucket			
Sonoma County Water Ag		275								

Table 11. (Cont'd.) SURVEY RESULTS--STORM WATER COLLECTION SYSTEM CLEANING

County City	Total Program Cost ($) (cc. – [illegible])	Program Cost/System Length ($)/mi. Closed	Open	Solids Collected (cu. yd.) Closed	Open	Program Cost/Amt. collected ($/cu.yd) Closed	Open
Contra Costa							
Concord		$1500/mi					
Richmond	120,000 - 15,000		3750/mi	12 cu yd	8 cu yd		
Walnut Creek							
Marin							
Corte Madera	$15,000	$1000/mi. reported					
Napa							
Napa	75,000	$1000/mi.					
San Mateo							
Belmont	15,000	← 2,500/mi.	→	← 350 cu yd	→	← $43/c.y.	→
San Mateo	30,000	← 440/mi	→				
Santa Clara							
San Jose	415,000	$410/mi					
Solano							
Fairfield	20,000 - 60,000	1342/mi.	6000/mi				
Vallejo Sanit. + Flood Control Dist.	64,000			34 cu yd		1900/c.y.?	
Sonoma							
Petaluma	10,000						
Rohnert Park	8,000						
Sonoma County Water Ag	O-C.: 100,000			15 cu yd	337 cu yd	—	297/c y

Values of $500 to $1500 per mile per year were obtained. Clearly in most cases only a small fraction of the entire system is cleaned in a particular year and thus costs per year of actual miles cleaned will be much higher. Lager reports the costs shown in Table 12.

4. Implications for Water Quality Management

There is insufficient data available to determine the effectiveness of storm sewer cleaning as a surface runoff control measure. It seems likely, however, that the volume of pollutants prevented from entering receiving waters is relatively small mainly because the materials removed from the storm sewers are generally the larger solid particles which do not carry as high a pollutant load as the small particles.

5. Cost-effectiveness

Insufficient data is available to allow calculation of a dollar cost per unit of pollutant removed.

Table 11

REPRESENTATIVE SEWER CLEANING COSTS

Storm Sewer Size	COSTS			
	$/cm diam per lin m	$/cm diam per lin km	$/in diam per lin ft	$/in diam per lin mile
Diameter ≤ 122cm (≤ 48in.)	0.095	95	0.075	396
Diameter > 122cm (> 48in.)	0.13	130	0.10	528

Source: Lager, 1977.

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APPENDIX

Catchbasin, Inlet, and Stormwater Collection System Cleaning Methods.

Catchbasin Cleaning Methods

Manual Cleaning. Workers use right-angle spoons, dippers or clamshell shovels to bail out basin water and remove sump material. They pile the solids on the street to drain and subsequently shovel them into trucks. A fire hose is used to flush the remaining dirty water and solids into the sewer.

Flushing. A high-pressure water jet is used to break up solids and flush all catchbasin contents into the sewer. This procedure defeats the goal of water quality enhancement.

Bucket Cleaning. A hydraulic crane with a specially designed orange peel or clamshell bucket is used to scoop out material from basins. The material is placed in a hopper on the crane and bucket truck or into separate dump trucks. This procedure is effective in removing most of the catchbasin contents but leaves some debris behind, to be flushed into the sewer.

Eductor Cleaning. An eductor is a water-operated suction pump capable of withdrawing solids and liquids from catch-basins. Workers lower the eductor hose from a motorized spool into the basin. The solid contents are sucked up and settle in the truck's holding tank. The liquid is cycled through the machine and returned to the basin.

Sometimes flushing is employed to break up solids. Large pieces of debris may require manual removal.

Vacuum Cleaning: An air-operated vacuum unit pulls liquids and solids from catchbasins into the truck. Here solids, liquid and air are separated by baffles and gravity. Air is expelled to the atmosphere; liquids are usually dumped into the basin or sewer to reduce trips to the landfill.

Effectiveness of Cleaning Methods. Manual and bucket methods fail to reach all of the solids in catchbasin sumps. These procedures also tend to lose solids on the street or, through flushing, into the sewer. Flushing alone is totally ineffective. Eductor and vacuum cleaning are the most effective in capturing solids and take the least time. A vacuum unit can usually pick up larger pieces of debris than an eductor.

None of these procedures reduce pollution from the supernatant liquid.

Inlet Cleaning

Inlets are cleaned by manual and vacuum cleaning methods, as previously described.

Stormwater Collection System Cleaning Methods

Closed conduits. Public works procedures for cleaning closed conduits can be classified within these categories: manual, drag bucket, ball (or tire), eductor, jet-rodder, vacuum, and hydroflushing. Brief descriptions follow.

Manual Cleaning. Workers use clam-shovels, scoop shovels, rakes, and brooms to clean material out of sewers. These methods can be used in accessible small pipes but are generally employed in very large diameter pipes. The debris is hauled away by dump trucks.

Drag bucket cleaning. A bucket machine with a cable and winch is used to pull a semi-circular bucket through the sewer. Usually the bucket machine, mounted on a trailer, is positioned near one manhole. Another portable winch is placed near a second manhole. Together the winches drag the bucket back and forth on a common cable, scooping up a bucketful on each pass.

This cleaning method can damage pipes. Bucket machines are usually used only when jet-rodders or vacuum machines cannot do the job.

Ball cleaning. An inflated ball or a Wayne sewer ball (attached to a rope) is placed in the sewer pipe. Water from a fire hose is then sprayed on it. The water simultaneoulsy scours the pipe around the ball and moves the ball down the pipe. A variation on this method utilizes a tire on a steel rim, or two tires on steel rims connected by a short length of pipe. The tires are obviously used for larger diameter conduits.

Eductor cleaning. The operation of an eductor is explained in the catchbasin cleaning discussion. To clean sewer conduit, a special revolving nozzle is placed on the hose. Blades on the nozzle can cut through solid matter. The jets of water clean away the solids and propel the hose and nozzle through the sewer. Sediment gathers in the eductor tank.

Jet-Rodder cleaning. A jet rodder machine consists of a high pressure pump, capable of ejecting water at 600-800 psi with a hose and a variety of tools and nozzles for the hose end. Workers place the hose inside the pipe. Water jets at backward angles clean the pipe and propel the hose forward. When finished a hydraulic reel retrieves the hose.

Vacuum cleaning. This method is described under catchbasin cleaning methods.

Hydroflusher cleaning. Hydroflusher units are usually smaller than jet-rodder or vacuum units. The hydroflusher has a powerful pump and high-pressure hose to blast solids from the insides of pipes. But none of the solids are retrieved; all flow down the sewer.

Performance of Cleaning Methods

Hydroflushing and ball (or tire) cleaning fail to reduce pollutant loads in receiving waters. Manual and drag bucket cleaning remove much but not all of the sediment. In addition, these methods may dirty streets.

Eductor cleaning, vacuum cleaning and especially jet-rodding are the most effective methods in removing sewer contents. Unfortunately eductors, vacuums and jet-rodders each have limits in terms of the size of pipe each can clean and the size of opening each one's hose can pass through.

Open Channels

Basically, open channel cleaning can be categorized as manual or mechanical. These modes are frequently used together.

Manual cleaning. Workers use clamshell shovels, scoop shovels, rakes, brooms, and buckets to remove debris. Dump trucks take the material away.

Mechanical cleaning. Depending on the type of channel (concrete conduit, ditch, creek) different machines may be used. A backhoe may dig sediment from a ditch or creek. A grader or bulldozer may sweep out a wide channel. A loader and dump truck may remove materials from the site.

Effectiveness. The performance of manual and mechanical methods in open conduits is directly related to how well they can dislodge or dig up sediments. This depends on specific site conditions.

WQ Tech Memo No. 50
S. Goldman

ENFORCEMENT GUIDELINES

FOR EROSION CONTROL INSPECTORS

March 18, 1980

A. INTRODUCTION

The foundation for erosion and sediment control in the Bay Area will normally be a city's or county's grading ordinance. (See Technical Memorandum No. 47 - Model Erosion and Sediment Control Ordinance). This ordinance sets the legal basis for regulating erosion and sedimentation. A good grading ordinance will require an erosion control plan prior to issuance of a grading permit. In the erosion control plan, each developer must provide detailed specifications showing how erosion will be controlled on a project site. The specifications provided by the developer should be equal to or surpass the standards and specifications found in a locally adopted Manual of Best Management Practices (ABAG is now preparing such a manual).

The combination of ordinance, manual and erosion control plan form the written requirements. One job of the construction inspectors is to ensure that erosion and sediment are controlled <u>on the actual site</u>. The purpose of this technical memorandum is to provide detailed information to enable the inspector to accomplish this task. After review by the Water Quality Technical Advisory Committee, this material will become part of the Specifications Manual for Surface Runoff Control Measures. It is recommended that each city and county adopt similar enforcement guidelines as official public works department procedures.

B. BASIC PRINCIPLES

Erosion is caused by rainfall and runoff. The energy of rain drops displaces soil particles. Rain falling on denuded or paved areas runs off, carrying soil particles down-slope and into stream channels. As the volume and velocity of the runoff increase, additional soil particles are removed from the channels. Deposition occurs when the water slows down, such as when channel slope decreases or when barriers or dams are encountered.

The foregoing provides the basic principles for erosion and sediment control:

1) Minimize area and duration of soil exposure

2) Protect soil with mulch and vegetation

3) Slow down velocity of runoff with structural control measures (berms, etc.)

4) Reduce volume of runoff through denuded areas by upslope diversions

5) Prepare drainageways to handle the increased runoff from paved areas

6) Trap sediment in temporary or permanent basins

7) Inspect sites adequately and maintain control measures.

C. ENFORCEMENT GUIDELINES FOR INSPECTORS

The following recommendations are based on current practices in Fairfax County, Virginia and Montgomery County, Maryland.

1. <u>Initial Site Review</u> (Preconstruction Meeting)

Prior to the start of work, meet the Field Superintendent at the site to review plan requirements. Go over the planned construction sequence and the corresponding schedule for installation of erosion and sediment control measures to see that the Superintendent has thought through all phases of the job. Go over with him all the notes. Look at the problem areas with him such as steep slopes above ponds and streams. On sites where soil may be particularly erodible it is recommended that an SCS or RCD advisor accompany the inspector on the first site visit.

Review the planned control measures with attention to these items:

(a) <u>Siting adjustments</u> - Locations of control measures in the plans may have to be adjusted to fit actual site conditions. If the controls do not make good sense, it is the inspectors responsibility to see that necessary adjustments are made. In addition, these changes should be brought to the attention of the department supervisor.

(b) <u>Alterations to Timing and Measures</u> - Judgment must be exercised in allowing or requiring changes as construction progresses. If the actual construction schedule varies from that specified in the grading plan, changes in control measures may be necessary.

2. <u>Start of Work</u>

(a) In general, erosion and sediment controls (dikes, dams, etc.) should be placed prior to or as the first step in grading.

(b) Dikes, stockpiles and dams should be seeded for temporary vegetative cover and mulched before October 1. Urge the contractor to use the site top soil for berm or dike material. This provides an out-of-the-way stock pile which is easily vegetated.

c) Read the weather reports. See that the Superintendent is ready for rain when it starts. Contractors are seldom prepared for rain, particularly the first rain.

d) Visualize runoff patterns during a heavy rain. Be sure that streams and storm drains below the site will not be damaged by runoff from such a storm.

e) See that unpaved site access roads which drain to existing roads have interceptors to prevent soil from being deposited onto the existinng roads.

f) Insure that the Superintendent has an information program to keep equipment operators aware of the locations and requirements for control measures so that they do not unintentionally destroy them. Likewise, there should be a program to keep vehicles, equipment and materials out of areas that do not have to be disturbed.

3. <u>Construction Continuation</u>

(a) <u>Inspector - Superintendent Relationship</u> - Maintain communications with the Superintendent; the job can't run well without mutual cooperation. Ask about progress reports. Ask him to prepare for removing controls as work approaches completion (if they need to be removed). The inspectors should deal with the Superintendent, not his subcontractors. If the Superintendent is habitually not available, contact the developer or owner.

(b) <u>Maintenance</u> Check maintenance of existing erosion controls; all sediment basins and traps need cleanout, and diversions need periodic reshaping and dressing. All dams should have a specified cleanout level which the inspector should be able to recognize. Especially check <u>storm inlet protection</u>. Dams and berms cut through for utilities should be restored the <u>same day</u>. All controls should be left in good shape at the end of each week. Make a special check whenever rain is forecast and see that the Superintendent has designated someone to check these things daily and to make repairs.

(c) Storm Drainage System - Watch development of the storm drainage system. As soon as any pipe is in the ground, manholes, inlet structures and walls should be installed so that proper controls can be built and the area will not have to be torn up again. As the system is built, attention must be turned to preventing sediment from entering the system. The volumes and velocities of water coming out at the endwalls are generally too great to control there. The control should be shifted to the inlets. As the site progresses, the inlet protection should change from excavated silt traps to rock filters at the throats or other equivalent measures. Do not use straw bales at throats or outlets at any time. Do not ever allow throats to be blocked.

(d) Drainage - Construction drainage: The site should drain so that it can be worked, but it should drain slowly so that a minimum of soil will be washed off-site. Ensure drainage of all traps -- every basin, whether that behind a large dam or the one at a storm sewer inlet must drain. Standing water is a hazard, a nuisance to construction and a problem for compaction. Additionally, a trap full of water has poor efficiency. If water remains ponded longer than 24 hours, see that drains and filters are cleaned out and reshaped.

Particular care is required if the construction is close to occupied buildings. Inlet protection should not prevent the inlet from functioning and possibly causing flooding of adjacent properties. Major sediment basins attract children and fencing is almost mandatory if there are occupied houses within 200 yards. Even with fencing, early drainage of each pond after a storm is necessary to reduce the possibilities of accidents.

(e) Fall seeding - Remind the contractor of the requirements for seeding and mulching. Tell him to get advice on this from the District Conservationist. Seeding equipment should be ready to go right after fine grading and seedbed preparations.

All seed and mulch should be in place by October 1. Check contractors preparations to meet this deadline. Make the contractor keep all controls operative until all the area above each control is fully stabilized. Seedbeds should be seeded the same day they are prepared. This practice will prevent the need for regrading and replacing topsoil on slopes.

(f) Stockpiles - Stockpiles of soil are commonly created which are not shown on the plans. All stockpiles should be seeded as soon as they are created, since they normally remain a long time. A diversion should be established above each stockpile. Do not let contractor cover up controls or bury trees with these spoils.

(g) Compaction - Poor compaction of berms, dams and fill slopes leaves highly erodible soil masses. Get the contractor to walk-in all fills in low lifts with tracked equipment or compactors. Cleat marks should be on the contour.

4. Construction Completion.

(a) Restoration - Ensure that all sediment dams, berms and other controls are remoqqd, regraded, seeded and mulched before demobilization. If any silt dam is to be left in place permanently (as shown on the plan), see that it is cleaned out and the embankment and bottom covered with a good stand of grass. Many diversions may be left in place but authorization should be obtained from the permit-issuing agency.

(b) Cleanup - Insist that any areas disturbed during final cleanup be seeded and mulched at once.

5. Violations

The following procedure should be used when reminders and verbal directives fail.

(a) First inform Superintendent and developer verbally that they are not in complianced

(b) If action is not taken within the specified time (a practical time for making necessary corrections), issue a written violation notice to the developer.

(c) The violations notice must contain the following:

o citation of the pertinent ordinance

o description of what the violation is and what must be done to correct it

o deadline for correction

o signature of inspector

(d) Submit one copy to department supervisor and one copy to the developer. (To eliminate criticism from developers, it is advisable for the inspector or his supervisor to give notice of the violation to the Superintendent on-site the same day the violations is written. This procedure gives the developer the benefit of the full amount of time granted for correction.)

(e) Follow-up violation notice with a site inspection on the last day allowed for correction or one or two days thereafter. Fill out a Violation Status Report which either:

    (1) releases the violation if the work has been done, or

    (2) indicates the work has not been done and makes a recommendation as to further action required.

(f) Submit copies of Violation Status Report to both department supervisor and developer.

Department supervisor then takes appropriate action pursuant to Section 403.01 et seq of the model grading ordinance (see Technical Memorandum No. 47).

WATER QUALITY MANAGEMENT PLAN

RECOMMENDED PLANTING TIME FOR VEGETATIVE STABILIZATION OF CONSTRUCTION SITES

Technical Memorandum No. 51

March 19, 1980
Revised August 29, 1980

A. RECOMMENDATION

Based on analysis of 30 years of Bay Area rainfall data, this memorandum recommends October 1 as the planting deadline for vegetative stabilization of graded areas on construction sites planting by October 1 provides:

- 90% probability that seeds will be in the ground before the first rainfall great enough to cause germination
- 90% probability that the first erosive rain will not occur for over 30 days.

B. INTRODUCTION

Vegetation is only effective as a construction site soil stabilizer if it provides enough ground cover to absorb raindrop impact, reduce runoff velocity, and increase soil permeability. Timing of seeding, germination, ground cover development, and first erosive rainfall thus represent significant factors in the effectiveness of any vegetative program of erosion control. The purpose of this memorandum is to establish, through empirical analysis of climatological data, the proper autumn planting date which maximizes vegetative cover establishment before the first erosive rain.

C. METHODOLOGY

Daily rainfall data was gathered over a 30 year period for four Bay Area locations. Fairfield, Oakland, San Jose, and San Mateo. (1) Means, standard deviations, 90% confidence intervals, and probability values were compared and analyzed. Distributions were assumed to be normal.

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1. US Department of Commerce, National Weather Bureau. "Climatological Data, 1946 - 79, Washington, DC.

To establish an optimum planting time three pieces of information were needed:

- Quantity of rainfall necessary to cause germination
- Length of time to produce sufficient ground cover
- Magnitude of rainfall great enough to cause erosion.

The following assumptions are based on consultations with Burgess Kay, Wildland Seeding Specialist at U.C. Davis. A germination-causing rainfall is defined as a 0.5 inch storm for minimal germination and a 1.0 inch storm for full germination. The length of time to produce sufficient ground cover varies widely due to weather conditions, soil type and slope. A minimum time of two weeks seems necessary, though four, six or more weeks would not be unusual. An erosion-causing rainfall includes all storms greater than 2.0 inches total.

D. DATA

Table 1 presents means and standard deviations of four San Francisco Bay Area locations and their average first 0.5 inch, 1.0 inch, and 2.0 inch autumn rainfall. Figures 1 and 2 graphically display the overlap in expected first dates of the different magnitude storms through the use of 90% confidence intervals and standard normal probability distribution curves. 90% confidence intervals describe time boundaries within which there is a 90% probability of the first rain occurring. The area beneath a distribution curve (See Figure 2) represents the probability that a rainfall will occur in that time period - 50% of the area means 50% probability of rainfall. Table 2 reveals the percent probability the particular planting dates will miss the first germination or erosive rain. Finally, Appendix Tables 1-4 provide the raw data from which all analyses were derived, and Table 5 presents probability figures for the first autumn rainfall of 0.5 inches, 1.0 inches, and 2.0 inches in the four Bay Area locations.

E. ANALYSIS AND CONCLUSION

It is commonly believed that the early autumn rainfalls are light and that, as the season progresses, storms gradually increase in frequency and intensity. Rainfall records support that assessment. Table 1 reveals that the average first germination-causing rainfall occurs around November 1 for all sampled Bay Area locations, and the average first erosive rainfall does not occur until well into December (Fairfield excepted). If those averages lacked variability, planting before November 1 would always yield sufficient ground cover to protect against later heavy rains.

TABLE 1

Means ($\overline{X}$) and Standard Deviations (S) for the first 0.5", 1.0" and 2.0" storms in autumn of four San Francisco Bay Area locations and the average of all four locations.

Oakland

	0.5"	1.0"	2.0"
$\overline{X}$	Oct. 31	Nov. 9	Dec. 8
S	23 days	24 days	28 days

Fairfield

	0.5"	1.0"	2.0"
$\overline{X}$	Oct. 29	Nov. 6	Nov. 28
S	25 days	26 days	30 days

San Mateo

	0.5"	1.0"	2.0"
$\overline{X}$	Nov. 1	Nov. 16	Dec. 8
S	22 days	27 days	28 days

San Jose

	0.5"	1.0"	2.0"
$\overline{X}$	Nov. 2	Nov. 24	Dec. 18
S	24 days	30 days	26 days

4-City Average

	0.5"	1.0"	2.0"
$\overline{X}$	Oct. 31	Nov. 14	Dec. 8
S	24 days	27 days	28 days

Note: If no rainfall equal to or greater than the threshold level (0.5", 1.0" or 2.0") fell before December 31 of a given year, for statistical purposes, the date of the first threshold rainfall was computed as December 31 (day 122).

Figure 1.

San Francisco Bay Area mean dates for first 0.5", 1.0" and 2.0" strength storms, with upper and lower 90 % confidence limits

FIGURE 2

Normal Distributions of data of first 0.5", 1.0" and 2.0" rainfalls in Autumn for the San Francisco Bay Area, California, with probabilities of first 0.5" and 1.0" storm depositing at least 2.0"

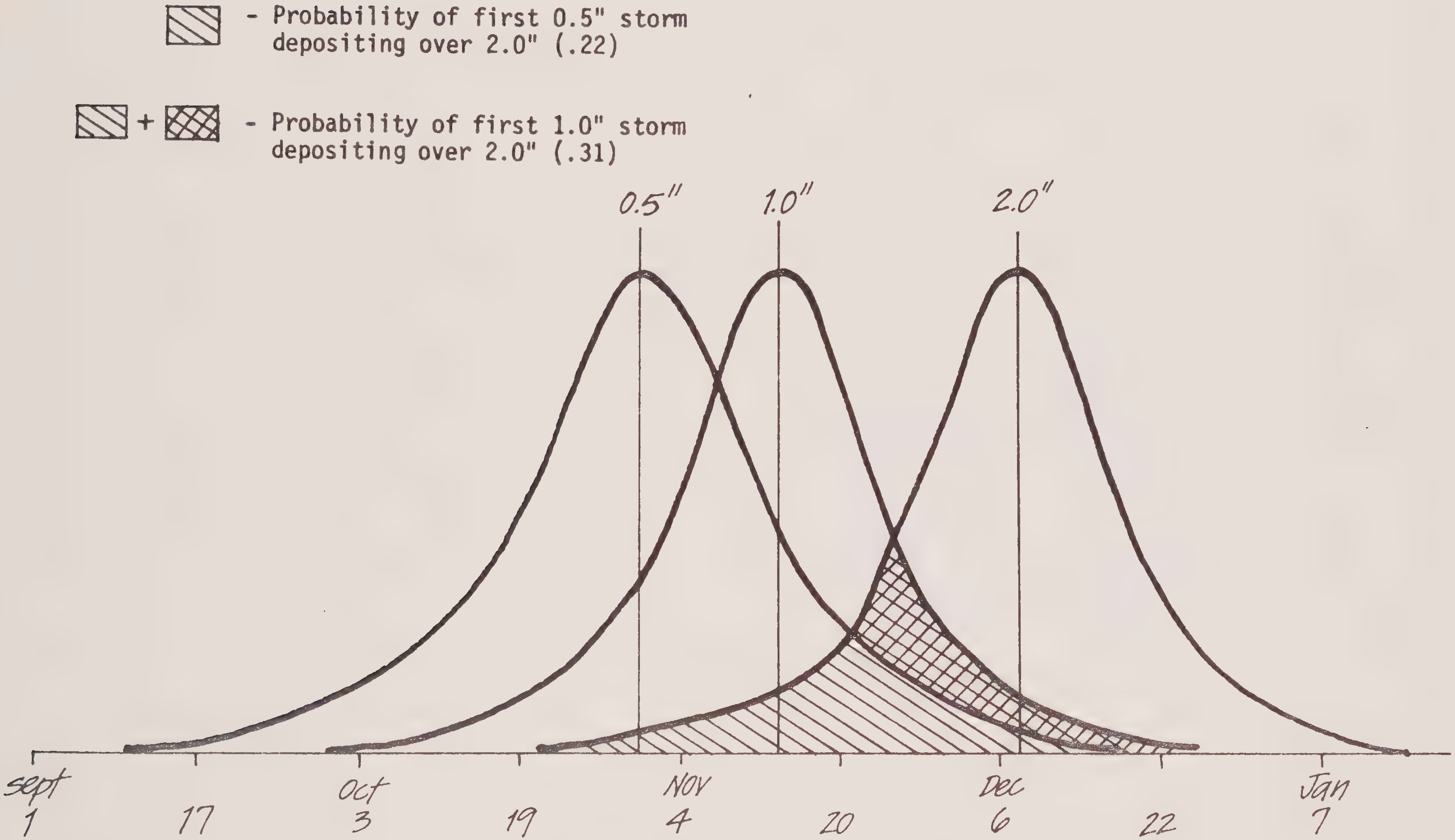

TABLE 2

Chance of missing first germination rain (0.5") and erosive rain (2.0") for selected dates. (Probabilities are based on the average for the 4 Bay Area locations.)

If you plant by	Your chance of missing the first germination rain is	Your chance of missing the first erosive rain is
Sept. 15	2%	<1%
Oct. 1	10%	<1%
7	15%	2%
15	25%	3%
21	35%	5%
Nov. 1	50%	9%
15	75%	20%
Dec. 1	90%	40%

Data variability does not allow that convenient conclusion. The 90% confidence intervals seen in Figure 1 display the overlap in dates from which it can be predicted with 90% certainty when the first germination and erosive storms will occur. The overlap in confidence intervals shown in Figure 1 indicates that it is possible for the first storm of the year to be greater than 2.0". That probability is quantified graphically in Figure 2. The overlap of the 0.5" curve with the 2.0" curve (the hatched area) is 22% of the area under the 0.5" curve. Thus, there is a 22% probability that the first storm greater than 0.5" is also greater than 2.0" The combination of both hatched and cross-hatched areas in Figure 2 shows the probability that the first storm greater than 1.0" will also be greater than 2.0". That probability is 31%.

As an example, in 1973, Fairfield experienced its first germination-causing rainfall on October 7 and its first erosive rainfall on November 12. If planting had occurred on October 1, vegetative cover would have been established before the first heavy rain. However, in 1959, Fairfield was drenched with over six inches of rain on September 18 and 19 - its first rainfall since the spring.

No planting deadline would have protected the ground from that anomaly. Vegetative erosion control practices can never fully replace the rigorous use of mulching and structural erosion control practices. Yet, selection of a planting deadline that provides an adequate probability of ground cover establishment at the minimum unnecessary inconvenience to developers is desirable.

Table 2 provides probabilities for germination-causing and erosive rainfalls at selected dates. Using this table, each jurisdiction can select a planting deadline giving the locally desired level of certainty.

However, planting by October 1 provides:

- o 90% probability of not missing the first germination-causing rain, and

- o 90% probability that the first erosive rain will not occur for over 30 days.

On the basis of these figures, this memorandum recommends October 1 as the planting deadline for vegetative stabilization.

APPENDIX

TABLE 1

Dates of first 0.5", 1.0" and 2.0" autumn rain storms in Fairfield, California, for years 1948-1977; September 1 = 1 and December 31 = 122

Year	Rainfall Amounts 0.5"	1.0"	2.0"
1948	47	117	-[a]
49	70	71	-
50	55	56	78
51	73	81	82
52	75	75	76
53	74	74	75
54	69	69	70
55	NA[b]	NA	NA
56	74	97	110
57	28	40	107
58	122	-	-
59	18	18	18
60	73	74	-
61	81	81	92
62	42	42	42
63	41	41	-
64	59	59	60
65	74	74	75
66	67	77	82
67	91	96	-
68	63	64	-
69	NA	NA	NA
70	NA	NA	NA
71	NA	NA	NA
72	NA	NA	NA
73	37	67	73
74	58	58	95
75	40	40	42
76	75	122	-
77	17	19	83

[a] No rainfall of that size during period

[b] Data not available

TABLE 2

Dates of first 0.5", 1.0" and 2.0" autumn rain storms in Oakland, California, for years 1942-1978; September 1 = 1 and December 31 = 122

	Rainfall Amounts		
Year	0.5"	1.0"	2.0"
1942	58	77	77
43	81	121	-[a]
44	60	61	-
45	59	59	60
46	NA[b]	NA	NA
47	31	39	-
48	103	117	117
49	70	70	-
50	55	56	79
51	73	80	82
52	74	75	97
53	74	74	-
54	70	72	-
55	74	97	111
56	NA	NA	NA
57	27	40	96
58	117	117	-
59	18	18	18
60	74	74	-
61	81	81	91
62	41	41	41
63	40	84	-
64	58	59	72
65	63	74	79
66	67	76	98
67	90	94	-
68	63	64	-
69	NA	NA	NA
70	NA	NA	NA
71	NA	NA	NA
72	NA	NA	NA
73	37	66	67
74	58	59	-
75	39	40	-
76	30	31	122
77	19	82	83
78	81	81	-

[a] No rainfall of that size during period

[b] Data not available

TABLE 3

Dates of first 0.5", 1.0" and 2.0" autumn rain storms in San Jose, California, for years 1942-1978; September 1 = 1 and December 31 = 122

Year	0.5"	1.0"	2.0"
	Rainfall Amounts		
1942	40	-[a]	-
43	121	-	-
44	61	61	-
45	59	60	-
46	NA[b]	NA	NA
47	39	-	-
48	108	122	122
49	70	-	-
50	56	56	80
51	80	81	-
52	75	75	-
53	74	74	-
54	76	93	-
55	78	109	110
56	NA	NA	NA
57	40	107	-
58	-	-	-
59	18	18	18
60	74	74	-
61	81	81	93
62	42	42	43
63	NA	NA	NA
64	59	71	73
65	74	75	77
66	67	83	98
67	90	91	-
68	64	64	-
69	NA	NA	NA
70	NA	NA	NA
71	NA	NA	NA
72	NA	NA	NA
73	37	37	-
74	58	94	-
75	60	-	-
76	29	30	-
77	19	-	-
78	82	83	-

[a] No rainfall of that size during period

[b] Data not available

TABLE 4

Dates of first 0.5", 1.0" and 2.0" autumn rain storms in San Mateo, California, for years 1942-1978; September 1 = 1 and December 31 = 122

	Rainfall Amount		
Year	0.5"	1.0"	2.0"
1942	41	78	78
43	51	121	-[a]
44	51	61	67
45	60	60	-
46	NA[b]	NA	NA
47	40	40	-
48	104	117	-
49	70	70	-
50	55	56	79
51	80	81	82
52	75	75	76
53	75	75	-
54	70	93	95
55	74	74	79
56	NA	NA	NA
57	27	29	107
58	117	117	-
59	18	18	18
60	74	74	-
61	81	81	93
62	41	42	42
63	41	66	-
64	59	71	72
65	73	74	76
66	67	77	96
67	90	91	-
68	64	76	-
69	NA	NA	NA
70	NA	NA	NA
71	NA	NA	NA
72	NA	NA	NA
73	37	66	67
74	58	122	-
75	41	56	-
76	31	121	121
77	66	106	108
78	81	83	-

[a] No rainfall of that size during period

[b] Data not available

TABLE 5

Probability of 0.5", 1.0" and 2.0" rainfalls occurring before Sept. 15, Oct. 1, Oct. 7, Oct. 15, Oct. 21, Nov. 1, Nov. 15 and Dec. 1 in Fairfield, Oakland, San Jose and San Mateo, California

Fairfield Rainfall Amount

Date	0.5"	1.0"	2.0"
Sept. 15	.0409	.0230	.0062
Oct. 1	.1340	.0834	.0250
Oct. 7	.2033	.1325	.0420
Oct. 15	.3045	.2090	.0723
Oct. 21	.3920	.2810	.1236
Nov. 1	.5478	.4220	.1782
Nov. 15	.7500	.6310	.3262
Dec. 1	.9052	.8289	.5349

Oakland Rainfall Amount

Date	0.5"	1.0"	2.0"
Sept. 15	.0262	.0114	.0012
Oct. 1	.1038	.0526	.0071
Oct. 7	.1660	.0918	.0139
Oct. 15	.2645	.1587	.0281
Oct. 21	.3540	.2255	.0446
Nov. 1	.5199	.3600	.0905
Nov. 15	.7433	.5925	.2020
Dec. 1	.9072	.8148	.3960

San Jose Rainfall Amount

Date	0.5"	1.0"	2.0"
Sept. 15	.0222	.0113	.0002
Oct. 1	.0901	.0401	.0014
Oct. 7	.1469	.0043	.0033
Oct. 15	.2372	.1038	.0080
Oct. 21	.3210	.1446	.0233
Nov. 1	.4820	.2310	.0359
Nov. 15	.7019	.3910	.1028
Dec. 1	.8859	.5964	.2555

San Mateo Rainfall Amount

Date	0.5"	1.0"	2.0"
Sept. 15	.0179	.0104	.0013
Oct. 1	.0838	.0430	.0074
Oct. 7	.1440	.0735	.0146
Oct. 15	.2413	.1251	.0287
Oct. 21	.3318	.1766	.1465
Nov. 1	.5050	.2912	.0934
Nov. 15	.7389	.4920	.2061
Dec. 1	.9131	.7157	.4031

APPENDIX

TABLE 1

Dates of first 0.5", 1.0" and 2.0" autumn rain storms in Fairfield, California, for years 1948-1977; September 1 = 1 and December 31 = 122

	Rainfall Amounts		
Year	0.5"	1.0"	2.0"
1948	47	117	-[a]
49	70	71	-
50	55	56	78
51	73	81	82
52	75	75	76
53	74	74	75
54	69	69	70
55	NA[b]	NA	NA
56	74	97	110
57	28	40	107
58	122	-	-
59	18	18	18
60	73	74	-
61	81	81	92
62	42	42	42
63	41	41	-
64	59	59	60
65	74	74	75
66	67	77	82
67	91	96	-
68	63	64	-
69	NA	NA	NA
70	NA	NA	NA
71	NA	NA	NA
72	NA	NA	NA
73	37	67	73
74	58	58	95
75	40	40	42
76	75	122	-
77	17	19	83

[a] No rainfall of that size during period

[b] Data not available

TABLE 2

Dates of first 0.5", 1.0" and 2.0" autumn rain storms in Oakland, California, for years 1942-1978; September 1 = 1 and December 31 = 122

	Rainfall Amounts		
Year	0.5"	1.0"	2.0"
1942	58	77	77
43	81	121	-[a]
44	60	61	-
45	59	59	60
46	NA[b]	NA	NA
47	31	39	-
48	103	117	117
49	70	70	-
50	55	56	79
51	73	80	82
52	74	75	97
53	74	74	-
54	70	72	-
55	74	97	111
56	NA	NA	NA
57	27	40	96
58	117	117	-
59	18	18	18
60	74	74	-
61	81	81	91
62	41	41	41
63	40	84	-
64	58	59	72
65	63	74	79
66	67	76	98
67	90	94	-
68	63	64	-
69	NA	NA	NA
70	NA	NA	NA
71	NA	NA	NA
72	NA	NA	NA
73	37	66	67
74	58	59	-
75	39	40	-
76	30	31	122
77	19	82	83
78	81	81	-

[a] No rainfall of that size during period

[b] Data not available

TABLE 3

Dates of first 0.5", 1.0" and 2.0" autumn rain storms in San Jose, California, for years 1942-1978; September 1 = 1 and December 31 = 122

	Rainfall Amounts		
Year	0.5"	1.0"	2.0"
1942	40	-[a]	-
43	121	-	-
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45	59	60	-
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52	75	75	-
53	74	74	-
54	76	93	-
55	78	109	110
56	NA	NA	NA
57	40	107	-
58	-	-	-
59	18	18	18
60	74	74	-
61	81	81	93
62	42	42	43
63	NA	NA	NA
64	59	71	73
65	74	75	77
66	67	83	98
67	90	91	-
68	64	64	-
69	NA	NA	NA
70	NA	NA	NA
71	NA	NA	NA
72	NA	NA	NA
73	37	37	-
74	58	94	-
75	60	-	-
76	29	30	-
77	19	-	-
78	82	83	-

[a] No rainfall of that size during period

[b] Data not available

TABLE 4

Dates of first 0.5", 1.0" and 2.0" autumn rain storms in San Mateo, California, for years 1942-1978; September 1 = 1 and December 31 = 122

	Rainfall Amount		
Year	0.5"	1.0"	2.0"
1942	41	78	78
43	51	121	-[a]
44	51	61	67
45	60	60	-
46	NA[b]	NA	NA
47	40	40	-
48	104	117	-
49	70	70	-
50	55	56	79
51	80	81	82
52	75	75	76
53	75	75	-
54	70	93	95
55	74	74	79
56	NA	NA	NA
57	27	29	107
58	117	117	-
59	18	18	18
60	74	74	-
61	81	81	93
62	41	42	42
63	41	66	-
64	59	71	72
65	73	74	76
66	67	77	96
67	90	91	-
68	64	76	-
69	NA	NA	NA
70	NA	NA	NA
71	NA	NA	NA
72	NA	NA	NA
73	37	66	67
74	58	122	-
75	41	56	-
76	31	121	121
77	66	106	108
78	81	83	-

[a] No rainfall of that size during period

[b] Data not available

TABLE 5

Probability of 0.5", 1.0" and 2.0" rainfalls occurring before Sept. 15, Oct. 1, Oct. 7, Oct. 15, Oct. 21, Nov. 1, Nov. 15 and Dec. 1 in Fairfield, Oakland, San Jose and San Mateo, California

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Date	0.5"	1.0"	2.0"
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Oct. 7	.2033	.1325	.0420
Oct. 15	.3045	.2090	.0723
Oct. 21	.3920	.2810	.1236
Nov. 1	.5478	.4220	.1782
Nov. 15	.7500	.6310	.3262
Dec. 1	.9052	.8289	.5349

Oakland Rainfall Amount

Date	0.5"	1.0"	2.0"
Sept. 15	.0262	.0114	.0012
Oct. 1	.1038	.0526	.0071
Oct. 7	.1660	.0918	.0139
Oct. 15	.2645	.1587	.0281
Oct. 21	.3540	.2255	.0446
Nov. 1	.5199	.3600	.0905
Nov. 15	.7433	.5925	.2020
Dec. 1	.9072	.8148	.3960

San Jose Rainfall Amount

Date	0.5"	1.0"	2.0"
Sept. 15	.0222	.0113	.0002
Oct. 1	.0901	.0401	.0014
Oct. 7	.1469	.0043	.0033
Oct. 15	.2372	.1038	.0080
Oct. 21	.3210	.1446	.0233
Nov. 1	.4820	.2310	.0359
Nov. 15	.7019	.3910	.1028
Dec. 1	.8859	.5964	.2555

San Mateo Rainfall Amount

Date	0.5"	1.0"	2.0"
Sept. 15	.0179	.0104	.0013
Oct. 1	.0838	.0430	.0074
Oct. 7	.1440	.0735	.0146
Oct. 15	.2413	.1251	.0287
Oct. 21	.3318	.1766	.1465
Nov. 1	.5050	.2912	.0934
Nov. 15	.7389	.4920	.2061
Dec. 1	.9131	.7157	.4031

WQ Tech Memo No. 52
K.A. Moy

MODEL PARKING ORDINANCE TO

INCREASE STREET SWEEPER EFFECTIVENESS

April 8, 1980
Revised 6/9/80

A. INTRODUCTION

Technical Memorandum No. 45 "Evaluation of Using Parking Restrictions to Increase Street Sweeping Effectiveness," (Bursztynsky, 1980) (hereinafter, TM 45) set forth parameters for determining circumstances in which parking restrictions are a cost effective measure for reducing street solid pollutant washoff. This memorandum presents a model which may be used by local jurisdictions to draft a parking ordinance in accordance with the analysis in TM 45 where the jurisdiction finds such restrictions are justified. Each jurisdiction should apply the analytical methodology formulated by TM 45 to its own circumstances. Where the results of such analysis indicate parking restrictions would be cost efficient, the jurisdiction should then determine whether such restrictions are compatible with other policies and planning goals. Some pertinent considerations are litter control, traffic flow, availability of alternative parking sites, especially in commercial and business areas and the development or availability of mass transit in the affected areas.

It is intended that the local jurisdiction use the model to draft either specific sections which may be incorporated into a pre-existing general ordinance or a single ordinance. Some sections appropriate to the latter purpose but inappropriate to the former have been included. The analysis identifies these sections.

Some features of the model are premised upon their compatibility with other policies and planning goals. These are also identified in the analysis.

B. ANALYSIS

Where a local jurisdiction chooses to amend an existing parking ordinance, some sections of the model ordinance should be adopted, either in the form presented or modified by the local jurisdiction, as separate sections. Other sections of the model ordinance indicate needed changes in the corresponding section of the existing ordinance.

§ 101.01 The importance of this section lies in explicitly designating water quality as a goal of the ordinance. It may not be appropriate to identify so specific a purpose in a general

ordinance where incompatible or conflicting goals are served by other sections.

§ 201.06. The local jurisdiction may not always find it advisable to tow vehicles parked in violation of the ordinance. It should provide enforcement personnel with clear and reasonable guidelines for the use or non-use of this procedure.

C. MODEL ORDINANCE

100.00 Title. This Chapter shall be known as the "(City) Parking Restrictions for Street Sweeping" and may be so cited.

100.01 Purpose. The purpose of this Chapter is to improve the effectiveness of street sweeping operations in removing street solids through the implementation of parking restrictions. The intent of this ordinance is to improve the water quality of receiving waters by reducing the amount of street solids in surface runoff.

100.02 Definitions. Whenever any words or phrases used in this Chapter are not defined in this section, but are defined in the Vehicle Code of the State of California and amendments thereto, the Vehicle Code definitions shall apply.

The following words and phrases when used in this ordinance shall, for the purpose of this ordinance, have the meanings respectively ascribed to them in this section.

(a) Curb Occupancy. The percentage of the curb length occupied by parked vehicles.

(b) Hour(s). Whenever certain hours are named herein, they shall mean standard time or daylight saving time as may be in current use in this city.

(c) Official Traffic Control Devices. All signs and markings placed or created by authority of the Director of ( ) (hereinafter "Director") under this Chapter.

(d) Park. To stand or leave standing a vehicle, whether occupied or not, otherwise than temporarily for the purpose of and while actually engaged in the loading or unloading of passengers or materials.

(e) Police Officer. Every officer of the Police Department of this city or any other person authorized to direct or regulate traffic or to make arrests for violations of traffic regulations.

(f) Stand. When prohibited means any stopping of a vehicle, and leaving same unattended, except when necessary to avoid conflict with other traffic or in compliance with the directions of a police officer or official traffic control device.

(g) Street. Street is a way or place of whatever nature, publicly maintained and open to the use of the public for purposes of vehicular travel. Except a street is not a highway and a highway is not a street.

201.01 Application of Regulations. The provisions of this Chapter prohibiting the standing or parking of a vehicle shall apply during those hours herein specified, except when it is necessary to stop a vehicle to avoid conflict with other traffic or in compliance with the directions of a police officer or official traffic control device.

201.02 No Standing and No Parking Areas. The Director shall designate pursuant to §301.01 areas wherein neither parking nor standing shall be allowed during specified hours.

No operator of any vehicle shall stand, park or leave standing said vehicle in an area designated by the Director pursuant to this section and §301.01, and for which area the Director has established appropriate signs or markings pursuant to §201.03.

201.03 Director to Establish and Maintain No Standing Zones and No Parking Areas. The Director shall establish and maintain, by appropriate signs or markings, all no standing and no parking areas as defined and described in this Chapter and shall give notice by appropriate signs or markings that vehicles parked or left standing in violation of such prohibitions are subject to removal from the street.

201.04 Violations. When signs or markings described in §201.03 are in place, it shall be unlawful and shall constitute an infraction for any operator of a vehicle to stand or park said vehicle in violation of said sign or marking.

201.05 Penalties. Every person convicted of a violation of this Chapter shall be deemed guilty of an infraction and shall be punished by a fine not to exceed \$(   ).

201.06 When Vehicles May Be Removed From Streets. Any police officer may remove or cause to be removed any vehicle parked or left standing upon a street when such parking or standing is prohibited by this Chapter and signs or markings giving notice of such prohibition and of such removal are in place. The operator(s) or owner(s) or record of such vehicles shall pay the reasonable cost of removing the vehicle.

301.01 Designation of No Parking and No Standing Areas. The Director shall designate each street named by the (City Council of   ) as a no standing and no parking zone during the hours said street may be serviced by a mechanical street sweeper. Such hours for each street shall be set forth in a schedule of street sweeper operations submitted to the Director and may be amended from time to time.

WQ Tech Memo No. 53
K. A. Moy

WATER QUALITY MANAGEMENT PLAN

Analysis of Watercourse Protection Ordinances

Technical Memorandum No. 53

April 15, 1980

INTRODUCTION

This memorandum surveys watercourse protection ordinances in effect in the ABAG region, analyzes their legal and institutional structures, and presents conclusion regarding the most effective use of such ordinances. Given the variety of legislation which may be classified as a watercourse protection ordinance, definition is the first step.

"Watercourse protection ordinances" shall refer to regulations applicable either to all activities within a defined area proximate to the watercourse or to only specific activities within the area. The regulated area varies in size, both among the different ordinances, and sometimes for the different applications of the same ordinance. The purpose of these regulations is either to prevent or to minimize the adverse effects caused by the regulated activity upon the water quality of the watercourse.

Potential water quality problems and their causal activities are set forth in Table 1. Table 2 further defines the harms incurred by such activities through a comparison of natural and affected watercourses.

ANALYSIS

Survey of Existing Legislation

As indicated in Table 3, the Federal, State and local governments all exercise jurisdiction over a given watercourse. In addition to these specific ordinances, many local land use regulations provide, either explicitly, or through the administration of same, for referrals to other regulatory bodies where the land use occurs in close proximity to or in a watercourse.

The Army Corps of Engineers (COE), the California State Department of Fish and Game (DFG) and local Flood Control Districts (FCDs) exercise regulatory authority, related to water quality, over Bay Area watercourses.

TABLE 1

ACTIVITIES OCCURRING IN PROXIMITY TO A WATERCOURSE AND THEIR POSSIBLE EFFECTS

Type of Activity	Actions or By-products	Direct Impacts to Watercourse	Associated Environmental Impacts
Construction or land disturbance	Grading-alteration of landforms making them more susceptible to erosion and exposure of bare soil to erosion effects	Increased sedimentation 10-2000 x background levels	Destroys stream bottom habitat; when silt exceeds 15%, damage to fish fry and invertebrates may occur; stream capacity is reduced
	Structures may be built on, over or within a watercourse	Restricts flow, severely disturbs bottom during construction	Damages habitat, disorients biota through increased turbidity, current diversions ,etc.
	Alteration of watershed increasing volume of surface runoff	Increased stream flow	Increases stream velocity, scour and channel erosion, changes stream environment
	Accumulation of construction materials and debris	Trash accumulation and contamination by harmful materials (oil, paint, etc.)	Alters stream flows (blockage) and may cause bio-toxicity
Agricultural practices and livestock grazing	Annual or semi-annual tilling, planting, harvesting up to stream bank	Increased sedimentation 20-100x beyond non-agricultural areas; fertilizer runoff nitrogen 0-8 lbs/acre, phosphorus 0-1 lbs/acre	See sedimentation above; fertilizer leaching contributes nutrients which may trigger algal blooms
	Grazing, overgrazing and uncontrolled livestock access to streams	Overgrazing increases erosion potential. Livestock access leads to trampling of stream bank and bed and depositing of fecal matter in/near stream	See sedimentation above; Destroys stream vegetation and bottom substrate; and contributes organic matter, bacteria, and excess nutrients to stream leading to unbalanced stream environment
Hydrodynamic Modifications	Dams or other structures to impede flow	Increased sedimentation in slow water areas, Stratification of water quality character	Silt/mud bottom leads to low reaeration and organisms tolerating low D.O. (worms, fly larvae)
	Water diversion	Decreased stream flow	Slow water favors algae/phytoplankton
	Channeling Culverting Rip-rap or other bank protection	Restricted laminar flows, uniform flows bottom shading, limited external interactions; removes vegetation next to stream	Poor reaeration, poor bottom habitat for biota, reduced vegetation; temperature increase 0-5°C
Dumping	Disposal of noxious substances (oil, detergents, etc.	Contribution of toxic or stimulatory materials (pesticides, metals, nutrients, others)	Biotoxicity, sublethal damage, food chain effects, algae blooms
	Disposal of domestic garbage and organic material (yard clippings, etc.)	Contribution of organic matter and nutrients, attracts pests	Decreases oxygen supply for organisms, contributes to algae blooms
	Disposal of trash and large items	Blocks or impedes flow, reduces stream capacity, degrades water quality	Limits migration of organisms

Activities Occurring in Proximity to a Watercourse and Their Possible Effects (Con'd.)

Type of Activity	Actions or By-products	Direct Impacts to Watercourse	Associated Environmental Impacts
Chemical Applications	Fertilizer application to planted areas	Increased nutrients, nitrogen and phosphorus	Possible ammonia toxicity, algae blooms
	Weed control	Herbicides, i.e., 2,3,D, Silvex Paraquat, etc.	Kills aquatic plants, biotoxicity
	Pest control	Pesticides, i.e. DDT, Dieldrin, etc.	Biotoxicity, magnification in food chain
	Vector control	Oil film on water surface	Kills mosquito larvae and affects organisms which come to water surface
	Wood preservatives on piers, decks, bridges	Pentachlorophenol, etc.	Acute toxicity to aquatic organisms
Landscaping or Maintenance	Vegetative clearing to reduce fire hazards and for aesthetic reasons	Increased erosion potential, removal of natural source of organic materials contribution to streams	Increased silt and sediments, reduction in natural organic food supply and micronutrients.
	Vegetative planting for aesthetics	New plants require more water and fertilizer which can runoff to stream	Nutrient enrichment leading to algae blooms
		Introduced plants may draw water from stream or out compete natural vegetation	Decreased stream flow, choked-up stream bottom

TABLE 2

COMPARISON OF NATURAL STREAMS AND STREAMS AFFECTED BY HYDRODYNAMIC MODIFICATIONS AND SURFACE RUNOFF

Stream Characteristic	Natural Stream	Affected Stream	Significance
Water Temperature	Relatively low, varies seasonally	0-5^{o} C higher than natural stream (shallower depths)	Decreases dissolved oxygen capacity of water (D.O.). Low D.O. and higher temperature can adversely affect sensitive species.
Nutrient Levels	Relatively high, varies seasonally	Excessively high (1-10x greater than natural)	Can trigger massive algae and phytophankton blooms which foul waterways and choke stream habitat.
Stream Banks	Variable, earth and/or rock depending on substrate	Variable, may have more unconsolidated soil than natural stream	Unstable banks have less vegetation, greater sediment erosion
Dissolved Oxygen Levels	Moderate-to-high; 7-12 mg/l	Low-to-moderate; 2-7 mg/l. Variable around algae.	Low D.O. reduces sensitive biota, favors tolerant worms, fly larvae, etc.; can lead to septic conditions on stream bottom.
Flow Regimes	Convergent and divergent flows	Little or no variability; usually laminar	Lower reaeration potential and stream mixing with laminar flows
Bottom Substrate	Coarse and fine materials	Relative uniform fine materials, flat	Low substrate diversity, fewer niches for invertebrates and fishes
Flow conditions	Pools and riffles - diversity of flows	Predominantly more riffles, flat, meandering and slower	Lower diversity in stream bottom, poorer habitat for invertebrates and fishes
Biological Productivity	High, balanced	Moderate-to-high, but unbalanced	Large numbers of 1-2 main species
Biological Diversity (species)	High	Low	Dominance of 1-2 main species, low species diversity, ecosystem unstable
Cover for Aquatic Organisms	Good	Fair-to-poor from "blanketing" of silt	Silt destroys habitat variations, leads to higher mortality for fish eggs and fry.
Vector Problems	Low	Moderate-to-high	Pools inaccessible to fish can develop mosquito populations

The COE is required, under P.L. 92-500 §404, to regulate the discharge of fill or dredge material into "navigable waters." Navigable waters have been so defined by COE regulations as to include most watercourses in the Bay Area. The COE reviews applications for permits to discharge dredge or fill material into a watercourse. In assessing the impact of the proposed activities on water quality as it relates to fish and game habitats, the COE usually defers to the judgment of DFG, see Fish and Wildlife Coordination Act. The COE also refers all permit approvals to the EPA for comment. Thus, as a practical matter, any activity falling under the jurisdiction of COE undergoes comprehensive environmental review.

The DFG, in addition to advising COE, exercises separate jurisdiction over any activity which may substantially divert or obstruct the natural flow or substantially change the bed channel, or bank of any watercourse where DFG determines that the watercourse is a significant fish and wildlife resource, see California Fish and Game Code §1601-1603. In defining such a watercourse, DFG considers a watercourse's potential for, as well as its actual ability to, support a fish or wildlife population. DFG is empowered to require the person undertaking the activity to adopt measures to protect the watercourse as a fish and wildlife resource. Arbitration and appeal to the judicial system are provided for those individuals challenging the DFG requirements. Local jurisdictions serve as a lead agency for DFG. Where no local agency exercises jurisdiction over an activity with potential for violating the criteria established by DFG, such activity may escape detection.

Concurrent with DFG, FCDs exercise jurisdiction over any activity which may alter the floodwater carrying capacity or drainage characteristics of a watercourse, or which may pose a flood hazard. While the primary goal of FCDs is flood prevention and hazard control, as indicated in Table 3, water quality concerns have been introduced into the FCD regulatory analysis, see SCWD and Napa FCD in Table 3. This change in perspective is compounded by FCD'S own hydrodynamic modification projects which often bring FCDs under DFG scrutiny. This interplay, to the extent possible under currently available technology, may cause more environmentally sound flood control practices.

Other local jurisdictions employ different approaches to regulating the area of a watercourse. One of the more obvious is land use zoning, see Solano County in Table 3. Such ordinances establish a protected area. The administrative agency then reviews requests to develop within that area. While grading ordinances do not usually incorporate water quality concerns, they are capable of reviewing grading applications for such concerns, see Water Quality Tech Memoranda Nos. 35 and 47. Finally, anti-littering ordinances will, by their language, also prohibit the dumping of refuse or other materials into a watercourse.

Problems of Controlling Activities Proximate to Watercourses

Watercourse protection ordinances proceed from two premises. First, activities within the regulated area will affect the hydrodynamic

TABLE 3

WATERCOURSE PROTECTION ORDINANCES

Agency	Enabling Legislation	Primary Goal(s)	Water Quality Criteria	Areal Jurisdiction	Activity(ies) Jurisdiction
Army Corps of Engineers	P.L.92-500 § 404	Water Quality	Preservation of water as habitat for fish	Below the headwaters of any watercourse	Any activity involving discharge of dredge or fill material into a watercourse with a flow >5 cfs
California Dept. of Fish and Game	CA Fish & Game C. §§ 1601-1603	Water Quality	Preservation of water as habitat for fish	Any watercourse supporting or capable of supporting a fish population and its banks	Any activity which may affect habitability of the waters
Santa Clara Valley Water District	Ordinance No. 74-1	Floodplain Management, Water Supply	Pollution by any material of water supplies	The watercourse and 50 feet on either side	Any construction or deposit of any materials in the area, planting or trespass
Napa County (FCD)	Ordinance No. 627	Floodplain Management	Preservation of riparian vegetation	100 year floodplain (FIRM) of designated watercourses	Construction, excavation, fill, clearing, planting, hydrodynamic modifications
Solano County	Ordinance No. 1090	Land use zoning, Water Quality	Preserve riparian habitat, control erosion and sedimentation	Designated watercourses plus 150 feet on either side	Excavation, fill, construction, maintenance, land disturbance and devegetation

characteristics of the stream so as to increase erosion, sedimentation, siltation, turbidity, etc. Second, such activities occurring in close proximity to a watercourse will increase surface runoff and introduce pollutants into the watercourse. An analysis of the problems and considerations attendant to the use of a general watercourse protection ordinance to deal with those two impacts is presented below.

Minimizing Hydrodynamic Changes

Analytically, the use of watercourse protection ordinances to prevent or minimize hydrodynamic changes adverse to water quality is straightforward. Where the technology exists, all activities in the watercourse would utilize methods and designs which reduce the environmental harm of hydrodynamic modifications to an acceptable level. Two problems, one of which is technical and legal, and one of which is political and legal in nature, are posed.

Riparian vegetation is centered to most watercourse protection ordinances. Vegetative cover along the banks of and in areas adjacent to a watercourse acts to stabilize the watercourse itself. The direct destruction of such vegetation clearly should be prohibited. However, the riparian vegetation zone is sensitive to changes in the environment adjacent to it. In order to maintain a viable riparian vegetation zone, it is arguable that an additional "buffer zone" to protect the ecotone area is necessary. The physical extent of such a buffer zone is not precisely by current technical and scientific knowledge. The degree of control necessary to support the primary riparian vegetation zone is also undetermined. In any event some minimum setback from the watercourse in which none but the most exigent activities are allowed is clearly supportable.

The other consideration in this branch of the analysis is competing public policies. The major agents of hydrodynamic modifications are local FCDs. Past overuse of hydrodynamic modifications as flood control measures may be traced in part to unwise development in flood prone areas which in turn necessitated strenuous flood control, and in part to a lack of viable alternatives. While a survey of current technology is beyond the scope of this analysis, one can presume alternatives to hydrodynamic modifications do exist for some situations and turn to an analysis of the situations where alternatives are not available.

In a straightforward confrontation between the long term goals and generalized benefits of water quality control and the disaster-related, spectacular problem of flood control, the latter has a distinct political advantage. A more profitable approach from a water quality viewpoint is to obviate situations where harsh hydrodynamic modifications are required. Essentially, this would entail controlling or eliminating development in flood prone areas. The impetus for such control currently exists in the form of the Nation Flood Insurance Program. The Napa ordinance weds the flood control requirements of the Division of Insurance and Mitigation of the Federal Emergency Management Agency to the water quality requirements of a vegetated and stabilized stream bank.

Minimizing Surface Runoff Pollution

The second purpose of a watercourse protection ordinance is the control of activities within the regulated area so as to minimize surface runoff pollution. In addressing this objective, two technical problems with legal and political overtones are prominent.

The first concern is the lack of data on the relative contributions of various activities wherever undertaken to the total excess sediment and runoff pollutant loads in a watercourse. Traditionally, the legal justification for government regulation in fields of activity wherein the basis for such regulation is unproven, lies in the perogative of the legislature to address pressing social problems "one step at a time." Addressing only specific polluting activities in a circumstantial area, as watercourse protection ordinances do, may fall under this legal rubric. Under these circumstances, the program should pursue the course of least resistance and least cost in controlling a particular problem.

No cost benefit analysis on watercourse protection ordinances is available. Napa County indicates administration and implementation of a permit system with a semi-annual aerial survey enforcement plan is inexpensive. However, enforcement against vegetation clearing is difficult and many of the projects reviewed are referred to DFG for technical review.

Without more data, one can infer that a generalized watercourse protection ordinance
is an inefficient tool where the agency of such an ordinance undertakes independent review authority. The wide range of activities occurs in close proximity to a watercourse. The agency must possess the expertise to review the myriad activities and resolve policy conflicts between water quality and a spectrum of other policy concerns from flood control to agricultural productivity.

A more orderly process in the legal, administrative and political sense may be had by making use of specific, institutions which currently oversee the particular activity. Water quality concerns may then be incorporated in the decision making processes of the particular institution.

The second technical problem focuses on the vast stretches of denuded or channelized watercourses in the ABAG region. Both theory and empirical data supports the premise that such areas will naturally revegetate. If we presume that such revegetation is desirable and possible, then the agency should provide a standard of performance or design criteria for promoting or allowing revegetation. Nothing in the current literature addresses the impact of surface runoff over denuded areas in regard to revegetation.

This gap in knowledge is of particular concern when, as noted above, there is also no data on the relative contributions of in-stream and out-of-stream activities to the total pollutant load. In-stream

stabilization through revegetation may be cost-effective where channel destabilization is a major contributor to the total load. Where surface runoff introduces sediment to the trough of the watercourse, it is critical to effective control that the effect of such sediment on revegetation be ascertained. The erosive environment of a stream channel is "natural" to riparian vegetation. Therefore, this natural level should be maintained. Alternatively, a watercourse protection ordinance may forego jurisdiction over such areas due to the lack of data on effective management techniques.

SUMMARY AND CONCLUSIONS

Pre-existing institutional control over watercourses is exercised by various agencies on all levels of government. They exercise their jurisdiction in the face of technical and legal shortfalls endemic to their purposes and objectives. These include a lack of legally sufficient data on:

- o effective measures to preserve riparian vegetation
- o relative contributions to the total sediment and pollution loading of a watercourse from various types of activities
- o the cost effectiveness of general watercourse protection ordinances
- o effective re-vegetation of denuded areas.

Apparently, water quality objectives are nonetheless achieved through the wedding of watercourse protection objectives to other public goals. The continued ability to meld watercourse protection criteria to other standards of review appears central to the viability of the watercourse protection concept.

The current dialogue between FCDs and the DFG is a sound basis for mitigating the effects of hydrodynamic modifications on water quality. FCDs probably undertake the majority of local hydrodynamic modifications projects. Review of private local projects is necessary to both FCDs' and DFG's legislative mandates and should continued. For the future, DFG should be given an enlarged areal jurisdiction, perhaps in line with its recommendations in its proposed Riparian Ordinance (April, 1980). FCD regulations may also be revised to include watercourse protection criteria as an intrinsic aspect of internal and external project review.

Vigorous lead agency work by local institutions would greatly augment DFG and FCD review. A watercourse protection ordinance establishing such a lead agency may be cost effective in some jurisdiction. In all cases, DFG and FCD funding would need to be increased either through legislative appropriation or payment by the local jurisdiction.

Where activities proximate to the watercourse have the potential to increase surface runoff or introduce pollution into the watercourse, such pollution problems should be addressed through agencies regulating the specific activity. This approach obviates the need for the political resistance to another permit agency.

In summary, insufficient technical data, and legal and political considerations do not adequately justify support of a new, specific watercourse protection ordinance. Where needed, local jurisdictions should seek to implement watercourse protection criteria through pre-existing institutions.

WQ Tech Memo No. 54
L. Jackson

WATER QUALITY MANAGEMENT PLAN

WATER QUALITY PROBLEM STATEMENT FOR OIL AND CHEMICAL SPILLS

Technical Memorandum No. 54
April 9, 1980
Revised 7/15/80
Revised 9/25/80

I INTRODUCTION

Oil and chemical spills, due to their unexpected and intermittent nature, pose unique water quality and management problems. Types of water quality problems that can be associated with spills include toxicants, pesticides, oil and grease, nutrient enrichment, organic wastes, low dissolved oxygen, litter and debris. Effects vary greatly depending on the substance and amount spilled. A large volume of a typically harmless substance such as milk can have a harmful effect equal to or greater than that of a small amount of a toxic material. The potentially severe impacts of spills upon the environment include fish kills, destruction of aquatic habitat and zooplankton, degradation of shore communities including commercial oysters and clam beds, fouling of beaches and reduction of aesthetic qualities, and harm to human health. Aquatic birds and mammals can also be adversely affected. Fish flesh may become tainted and fish production lowered. Concern is also rising as to potential chronic impacts from the cumulative occurrence of spills.

II EXTENT OF PROBLEM

Numerous oil and chemical spills are reported each year throughout the Bay Area by various agencies. Agencies that monitor spills include the U.S. Coast Guard, the Environmental Protection Agency, the Department of Fish and Game, California Office of Emergency Services, Regional Water Quality Control Board and Caltrans. Since agency jurisdictions often overlap and not all spills are reported, it is difficult to collate spill reports and assess the total occurrence of spills in the Bay Area. At the minimum, there is an average of one spill recorded in the Bay Area each day. A survey of primary response agencies reveals the following data which are summarized in Table I:

- The U.S. Coast Guard (CG) has responsibility for prevention and cleanup of spills in the coastal area of the San Francisco Bay and its tributaries, and the Sacramento-San Joaquin Delta. On the average, the CG identifies 360 spills of oil and hazardous materials a year (1). Most of these spills are oil, with only 2% being other hazardous materials. The disparity is likely due to the fact that most chemical spills do not leave obvious physical evidence as do oil spills.

TABLE 1

OIL AND CHEMICAL SPILLS REPORTED IN THE BAY AREA ANNUALLY

Reporting Agency	Average Number of Spills/Year[a]	percent			
		Oil	Hazardous Materials	Non-hazardous Materials	Unknown Substance
Coast Guard (1)	360	98	2[b]	--	--
Environmental Protection Agency (2)	200	60	24[c]	5	11
State Department of Fish and Game (3)	127	58	21[d]	9	12
Caltrans (5)	160	4	17	78	1
State Office of Emergency Services (7)	170	nda	nda	nda	nda

[a] Due to overlapping jurisdictions, spill counts from each agency should not be added together to give a total annual count for the Bay Area.

[b] Hazardous materials, defined by Title 49 CFR, Part 172, list of 1260 materials.

[c] Hazardous substances, defined by Title 40 CFR, Part 117, list of 299 materials.

[d] In practice, DFG considers any substance potentially hazardous to waterways. However, the California Administrative Code, Title 22, Division 4, Chapter 30, Article 8, identifies 791 materials as hazardous.

- The Environmental Protection Agency (EPA) has jurisdiction over inland spills and reports about 200 spills a year (2). Due to the complex network of waterways in the region, both the Coast Guard and EPA may report the same spill. Therefore, total spill counts from each agency can not be added together.

- As most spills pose a threat to fish and wildlife, the State Department of Fish and Game (DFG) is usually notified. Some spills go unreported until their impacts, such as fish kills, become visible. In these situations, the DFG becomes the primary response agency. Currently, DFG records about 120 spills a year (3), many of which are also recorded by the CG and/or EPA. Unfortunately, limited staff restricts the number of spills the DFG are able to investigate.

- The Regional Water Quality Control Board (RWQCB) and DFG are the primary agencies most actively involved with enforcement actions pertaining to spills. A memorandum of understanding between the two agencies delegates enforcement responsibilities to DFG for incidents of 10 barrels or less and to RWQCB for those spills greater than 10 barrels. The RWQCB does not attempt to log all spills occurring in the Bay Area. They do investigate about 50 spills of gasoline or oil per year (4), all of which should be on the CG list.

- Caltrans and/or the California Highway Patrol (CHP) respond to spills on state highways and county roads. Caltrans is responsible for cleanup, whereas the CHP is concerned with safe traffic movement. Caltrans reports an average of 34 oil and hazardous material spills a year in the Bay Area (5). The CHP have recently begun to compile a state-wide log of spills, the total of which is presently 2% of that reported by Caltrans (6).

- California State Office of Emergency Services (SOES) has a hotline for receiving reports on spill incidents, recording pertinent information and notifying appropriate response agencies. At present, there is no log available on spills reported to SOES. It is estimated that about 170 spill reports are received each year from the Bay Area (7). Coast Guard data indicates that about 25% of all "spills" reported to them by SOES are negative sightings, meaning that investigation reveals no evidence of a spill.

- Local fire departments are usually called for spills occurring within cities and off state highways, with some involvement of police and public works personnel. Few fire departments keep records of spills. The Oakland Fire Department is one of the few and estimates a response to 950 calls on spill and leaks each year; this includes both surface and subsurface spills (8). Some local spills may be reported to the appropriate state or federal agency, but it would be difficult to determine the number that go unreported.

- This memo focuses on surface spills, however, concern is increasing as to the extent of subsurface hazardous material spills. The RWQCB conducted a survey in the Bay Area from August 1977 to March 1978 revealing 86 incidents of leakage from underground gas storage tanks. The total estimated amount of material lost was 122,730 gallons (9).

III SPILL REPORTING AND HANDLING PROBLEMS

The difficulty in determining the overall incidence of oil and hazardous material spills in the Bay Area reflects several regulatory and management problems. From a water quality viewpoint, the following institutional problems are particularly apparent in the handling of spills.

Spills Never Reported

Due to the nature of spills (variable cause, severity, visibility and location) some spills are never reported to any agency. All carriers of hazardous materials are required to report spillage, regardless of amount. Vessels discharging into the Bay have good reporting histories. Due to penalties for not reporting a spill into the Bay there are often multiple reports of a single spill. However, reporting of inland spills is not as thorough. According to the CHP, there are a great number of spills that go unreported (6).

Jurisdictions Overlap

As evidenced in Table I, the profusion of agencies involved with the handling of oil and chemical spills, each with some areas of independent and/or overlapping jurisdicitons, makes it difficult to compile a comprehensive list of recorded spills. There is disparity among agencies reporting spills within the same jurisdictions, e.g., Caltrans and CHP. There appears to be a lack of a Bay Area regional coordination of the efforts of these agencies and the development of common policies and objectives. Although jurisdictions overlap, the perspective of each agency's approach has led to inconsistencies in cleanup practices.

Lack of Available Data on Spills Responded to by Local Fire Departments

Although some local fire departments keep records of spills and/or notify the CG and DFG, most local spills are not recorded or, if so, not compiled in a separate log. Aside from the value of knowing the number of spills responded to throughout the Bay Area, the recording of spills would provide data on the cleanup method used. Fire department capabilities to handle spills have increased substantially in recent years. Most cities feel prepared to deal with a hazardous chemical spill (10). However, some fire departments lack special training and equipment to respond appropriately.

As an example, ABAG staff witnessed a truck spill about 20 gallons of cleaning solvent on Tunnel Road in Berkeley. By the time the fire department arrived, some of the solvent had reached a nearby storm drain. The fire department responded by washing the solvent into the storm-drain with water, then with soapy water. Sand was then put on the solvent

remaining on the road surface. The fire officer on the scene reported to the policemen writing a report that the spill was less than five gallons, so it need not be recorded.

Reporting of Spills Focused on Oil and Hazardous Materials

Most agencies' responsibilities and contingency plans focus on oil and hazardous materials. Similarly, carriers of hazardous commodities are required to report any spillage, whereas this does not apply to non-hazardous materials. As noted in Table I, most of the recorded spills are oil or hazardous materials. Assuming similar accident rates for carriers of non-hazardous and hazardous materials, it is estimated there are 20 times more spills related to trucking than recorded. This figure is based on a California truck inventory and use survey in which 1.8 percent of the trucks not used for personal transportation carried hazardous materials as defined in CFR, Title 49 (11). In assessing types of products carried, an additional 37 percent of the trucks transported items posing potential spill problems to waterways.

Definition of Hazardous Substances Vary

Various lists defining and identifying hazardous materials have been developed at Federal, State and local levels. As footnoted in Table I, these lists are not always consistent. Hazardous materials are typically defined in terms of corrosive, flammable, toxic, irritating and potentially reactive properties. However, seemingly non-hazardous materials when washed into waterways can have an extremely adverse effect on aquatic life, destroying habitat and leading to fish kills.

As an example, about 1800 gallons of raw red wine, spilled from a transport accident in Fairfield, was washed into a storm drain by the local fire department. The wine eventually drained into Suisun Creek causing a fish kill. Once notified, the Department of Fish and Game ordered sand dumped into the storm drain and vacuumed up. In another incident, 5000 gallons of milk spilled from a truck accident in Richmond. Milk flowed into a nearby storm drain and thence to the Bay, adding nutrients and lowering dissolved oxygen levels in the immediate receiving waters.

Inconsistent Response Policies for Containment of "Non-Hazardous" Materials

The problem in defining a hazardous material becomes evident with the handling practices for typical non-hazardous materials. A general survey of agencies responding to inland spills indicated varying emergency response plans for oil and hazardous materials. However, the standard cleanup practice for obvious non-hazardous materials is usually washdown into the nearest storm sewers and thus draining into a local stream, lake and/or the Bay. See Table 2. Most fire departments contacted were unaware of the potential water quality problems associated with such washdowns.

TABLE 2

PRELIMINARY SURVEY OF LOCAL HANDLING OF

NON-HAZARDOUS MATERIALS SPILLS

Agency	Spill plan/policy for containment of non-hazardous materials
ALAMEDA	
County Office of Emergency Services (COES)	Yes
Berkeley Fire Department	No
Oakland Fire Department	No
Livermore Emergency Services	No
CONTRA COSTA	
COES	Yes
Contra Costa County Fire Protection District	No
Richmond Fire Department	Yes
MARIN	
COES	No
Marin County Fire Department	No
Tiburon Fire Department	No
NAPA	
COES	No
Napa Fire Department	No
SAN FRANCISCO	
COES	No
San Francisco Fire Department	No
SAN MATEO	
COES	No
Redwood City Fire Department	No
SANTA CLARA	
COES	No
San Jose Fire Department	No
SOLANO	
COES	No
Vallejo Fire Department	No
SONOMA	
COES	No
Santa Rosa Fire Department	Yes
CALTRANS	Yes

IV SUMMARY

In brief, the handling of a spill is influenced by a series of events. When a spill occurs, it may or may not be reported. When reported, the method of handling depends on the responding agency's/agencies' definition of hazardous and subsequent cleanup practices. Although numerous contingency plans addressing each response phase have been developed by responsible agencies, there seems to be a lack of consistency among the network of response plans. Coordination among response agencies insures that common objectives and goals are achieved. This is evidenced by the cooperative efforts of the Coast Guard, RWQCB and DFG. Lack of coordination gives way to the individual objectives of each response group. This seems to be more apparent at the local level, particularly from the viewpoint of this memo, where there is a general lack of awareness of water quality problems.

V RECOMMENDATIONS

Policy 12 of the Water Quality Management Plan states "Monitor effectiveness of existing arrangements for preventing and dealing with oil and chemical spills in Bay Area." Action 12.4 more specifically recommends the development of local roadway and railbed spill containment and cleanup capabilities. This calls for local fire departments to prepare plans for dealing with a variety of spilled chemicals. Pursuant to these items, the following recommendations are made:

1. Coordinated response program

   The reporting and handling problems outlined above reflect the general lack of consistency among local, State, and Federal agencies in dealing with oil and chemical spills. It is recommended that a coordinated program be developed in the Bay Area dealing with these spills. The focus should be on training the initial response personnel.

2. Containment of all chemical spills

   The definition of a hazardous spill is open to the interpretation of each responding agency. The definition of hazardous needs to be expanded beyond the typical categories to include damage to the aquatic environment. Due to the potential pollution effect on receiving waters, the recommendation is made to contain all chemical spills for subsequent collection and disposal in an appropriate area.

UPDATE

On July 17, 1980, the following actions were incorporated into the Bay Area Water Quality Management Plan:

- Action 12.8 Ammend county spill plans to include containment of all non-hazardous chemical spills exceeding 100 gallons.

  Responsible Agency: County Offices of Emergency Services, fire departments with independent plans

  Schedule for Action: By June 1981

- Action 12.9 Prepare and implement a regionally coordinated chemical spill response plan.

  Responsible Agency: ABAG, County and State OES, fire districts, county health agencies, police services, RWQCB, Fish and Game, Caltrans, manufacturers, transporters

  Schedule for Action: Commence in 1980-81

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WQ Tech Memo No. 55
L. Jackson

WATER QUALITY MANAGEMENT PLAN

EROSION-RELATED WATER QUALITY PROBLEMS

Technical Memorandum No. 55
May 1980
Revised September 2, 1980

I. INTRODUCTION

Although erosion and sedimentation are natural processes, they are greatly accelerated by construction, mining, agricultural practices, wildfires and recreation. Erosion leads to turbidity and deposition of sediments which clog storm sewers and stream channels, reduce lake and reservoir capacities, and account for significant portions of nutrient and heavy metal loadings to Bay Area waters. Erosion also may severely impact aquatic life. Briefly described here are the extent of these problems, impacts on aquatic life and some of the costs associated with these problems.

II. EXTENT OF PROBLEM

Erosion of soil and deposition of sediments in waterways is a serious ecological and economic problem in every Bay Area county. Erosion and sedimentation have been identified as the principal surface runoff problem to be addressed by cities and counties in the Environmental Management Plan. The annual sediment mass balance has been estimated for the Bay Area and is presented in Figure 1. Sediment yields from local watersheds draining to the bay were calculated from typical erosion rates associated with the various land uses. This drainage area covers 2,921,600 acres and represents 96% of the 208 Planning Area. Average rates of deposition to local lakes, reservoirs and Bay were subtracted from the total watershed sediment yield to estimate amounts deposited in streams, channels, catch basins, storm drains, etc. Sediment yield from the local watershed is combined with the volumes of sediment flowing in from the Delta to present total sediment inflow to the system. The following points describe this sediment mass balance and illustrate the seriousness of the problem:

- That portion of the nine Bay Area counties which drains into the Bay produces approximately 8.3 to 9.4 million cubic yards per year of waterborne sediment. It is estimated that 2.7 to 3.1 million cubic yards are deposited in lakes and reservoirs throughout the area, 3.1 to 3.5 million cubic yards are deposited in streams and channels, and 2.5 to 2.8 million cubic yards ultimately wash into the Bay.

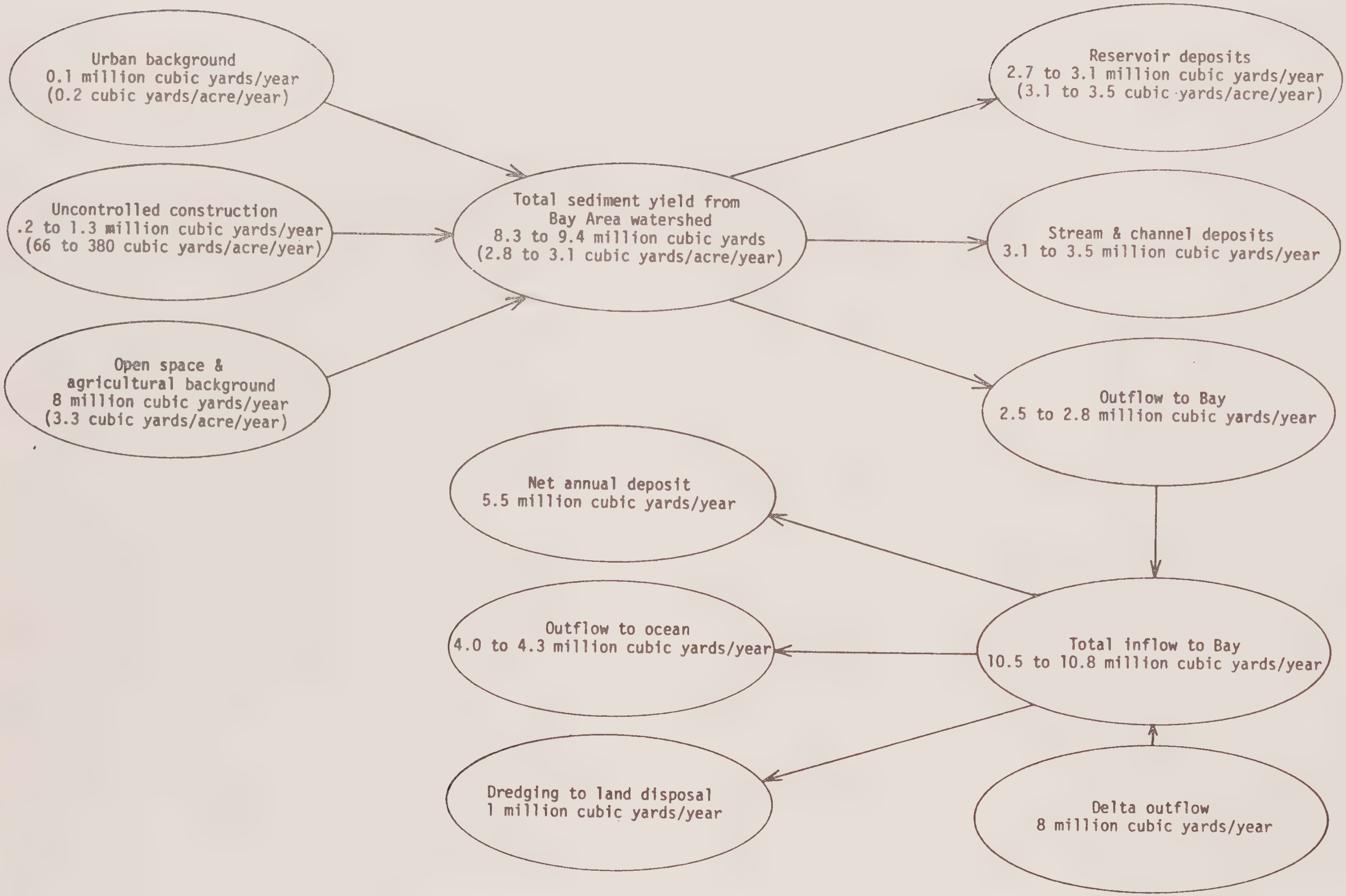

Figure 1. ESTIMATED ANNUAL SEDIMENT MASS BALANCE FOR SAN FRANCISCO BAY AREA

Note to Figure 1: Estimated Annual Sediment Mass Balance for San Francisco Bay Area

Since much of the quantifiable effects and costs associated with sedimentation relate to dredging and loss of reservoir capacity, the data in this Figure have been presented on a volume basis (cubic yards). However, sediment densities vary considerably. It is useful, particularly to the soil scientist, to present the same data in terms of dry specific weight. The density of sediments depends on the character of the soil materials, variables of transport mechanics and the amount of superimposed load to which it is subjected. Volumetric data can be converted to dry weight using the following conversion factors, noting the different conversion factors relative to the type of sediment. For example, particles deposited along stream beds are likely to be larger and denser than the fine sediment reaching the Bay.

Average Dry Unit Weight of Sediment	lb/cubic foot	Tons/cubic yard
eroded from watershed/deposited in reservoirs	75	1
deposited in streams and channels	75-110	1-1.48
deposited in Bay	33	0.44

- Construction activities increase soil erodibility from 10 to 2000 times, with values of 15-20 times commonly reported in the Bay Area. Due to the relative magnitude of and variability in erosion rates on construction sites, sedimentation rates in Figure 1 are presented as a range. At an average increase in urban/residential areas of 3520 acres per year, construction without erosion controls could produce 0.2 to 1.3 million cubic yards of sediment annually. Although areas under construction annually represent only 0.1% of the total land, they contribute 2 to 14% of the sediment to the system. It is assumed that this range is distributed proportionately to the reservoirs, streams and Bay.

- Due to lack of data, excessive sedimentation due to major storm events, landslides, and non-agricultural practices are not accounted for in the Sediment Mass Balance (Figure 1). The open space and agricultural background was calculated on an average sediment rate reported from local watersheds.

- A U.S.G.S. study of Colma Creek, San Mateo County, found that during construction, 72 percent of the sediment leaving the basin originated from 14 percent of the area.

- A Santa Clara County study of Calabazas Creek, part of the 208 surface runoff program, revealed that 72% of the sediment discharged from the watershed was generated from 6% of the area. New construction would almost double the 12,000 cubic yards per year average discharge from the watershed.

- The following are examples of average annual lake sedimentation rates in the Bay Area.

Lake	Drainage Area Acres	Annual Sedimentation Cubic Yards	Rates, Cubic Yards/Acre	Land Use
San Pablo, Contra Costa	20,480	170,000	8.3	Recreation, Open Space, Grazing, Residential
Upper San Leandro, Alameda County	19,840	150,000	7.6	Natural
Cull Canyon, Alameda County	4,032	24,000	6.0	Grazing, Residential, Construction
Uvas, Santa Clara	19,200	24,500	1.3	Grazing, Recreation
Temescal, Alameda County	1,533	860	0.6	Recreation, Natural, Residential
Lake Merritt, Alameda County	6,400	2,000	0.3	Urban

- As noted above, the average annual sedimentation rate for Lake Temescal is about 0.6 cubic yards per acre. During 1907 to 1963, a period of considerable residential and road construction, sedimentation averaged over the entire watershed was 2 cubic yards per acre. From 1963 to 1973, major highway construction took place in the watershed, increasing annual sediment yield to 5.5 cubic yards per acre.

- Approximately 8 to 10 million cubic yards of sediment are dredged from the Bay annually by the Federal Government and private concerns. One million cubic yards of this sediment are disposed on land, with the remainder disposed in specific aquatic sites.

- Mare Island Strait is the most heavily dredged site, where about 2 million cubic yards of sediment are removed twice a year.

- Local surface runoff produces 38 percent (2200 tons/year) of the heavy metals discharged to the Bay, much of which are adsorbed to sediment particles.

- Bay Area soil erosion accounts for a significant portion of the annual nitrogen (2140 tons) and phosphorus (214 tons) load to Bay waters, with an immediate impact on inland streams and reservoirs.

III. AQUATIC HABITAT IMPACTS

Although data quantifying the impacts of excessive sedimentation (or of the associated pollutants) on aquatic biota are not readily available, there is little disagreement about the nature of these impacts:

- Erosion of streambanks and adjacent watershed areas can destroy riparian or streamside vegetation that is important in moderating climatic extremes as well as providing aquatic and wildlife habitat.

- Excessive deposition of sediments in streams blankets the bottom fauna and literally "paves" a stream bottom into a flat, unnatural environment. A recent case occurred in Wildcat Canyon, Richmond, due to construction. This case was referred to the State Attorney General for prosecution. The developer has subsequently been required to install sedimentation basins and incorporate best management practices into his activities.

- Turbidity from high stream sediment loads can reduce in-stream photosynthesis leading to reduced food supply and habitat.

- o Excessive nutrients contributed from surface runoff can trigger major algal blooms that choke waterways, deplete oxygen, lead to fish kills, and create foul odors.

- o Physical changes in the watercourse such as blockage, scouring or diversion, coupled with water quality deterioration from runoff contaminants leads to the disorientation of fish and aquatic life and the decline of stream health.

- o Aquatic organisms may be damaged directly by abrasion and coating action of certain size particles.

- o About two-thirds of the marshlands in the Bay Area have been destroyed. This is primarily due to diking, dredging, filling and the process of erosion and sedimentation. Wetlands are some of the region's most productive habitats.

- o It has been estimated that the application of residue management on croplands potentially increase habitat quality ratings by 50% (USDA, 1980).

IV. ECONOMIC IMPACTS

Erosion and sedimentation is one of the few surface runoff problems that have partially quantifiable economic impacts, particularly on local governments. Most available cost data are related to off-site problems. These are the common costs incurred in the lower reaches of the system where dredging is necessary to remove sediment build-up. On-site costs are more significant in rural areas and relate to the value of the soil lost. Many of the economic impacts are unquantifiable, yet are just as important. Unfortunately, this is the case for biologic impacts where an accurate economic assessment is not available.

<u>On-Site Costs</u>

- o Erosion selectively removes the smaller and less dense constituents of topsoil. These are clay particles and organic material which are the constituents that store nutrients in a form available to plants. The total value of plant nutrients lost is estimated to be $6 per cubic yard of eroded topsoil (USDA, 1980). This would equate to an increased fertilization cost in the Bay Area of about $50 million.

- o Removal of loose topsoil with its good infiltration and water holding and rooting characteristics is also damaging. Another way to estimate the cost of erosion is replacement cost. At the $8 per cubic yard cost of topsoil, the total value of soil loss in the Bay Area would be $70 million.

- o Eroded soils produce less vegetative growth and are harder to till than similar soils that have not eroded. Studies indicate that 10-80% more energy is needed to till eroded soils (USDA, 1979).

Off-Site Costs

Reservoirs

- o Excess sediment accumulation reduces reservoir storage capacity, which leads to increased dredging or early replacement.

- o Ten years after construction of Cull Canyon Reservoir, 400,000 cubic yards of sediment were removed for about $1 million.

- o The East Bay Regional Park District recently spent $750,000 to dredge 47,200 cubic yards of sediment from Lake Temescal. About 30,000 cubic yards had been dredged from the lake 11 years earlier.

- o Proposed control measures for cleaning Lake Merritt include dredging at costs of $2 - 7 million to remove up to 700,000 cubic yards of sediment. Follow-up maintenance dredging costs are estimated at $20,000 - 200,000 per year.

- o Reported dredging costs range from $2.5 to $16 per cubic yard. At a typical dredging and disposal cost of $10 per cubic yard, the calculated cost for cleaning sediment from all the lakes and reservoirs would be $30 million per year. Actual expenditures are less, since many of the larger reservoirs are allowed to fill up where dredging costs would be prohibitive in terms of the unit cost for additional water storage.

- o San Pablo Reservoir is an example where it is presently not cost effective to dredge. The cost to remove and dispose sediment accumulated in the reservoir is estimated to be $12 million.

- o Early replacement of large reservoirs calls for the acquisition of new reservoir sites. However, increases in land value and pressure from various land use interests may reduce the availability of new sites. Despite the high costs, large scale dredging may become a feasible alternative.

- o Nutrient enrichment, due in large part to sediment inflow, has led to several lake restoration programs. Cleanup programs are presently underway for Lake Merritt, Lake Temescal, San Mateo Lagoon, and Stafford Reservoir. The total cost of these programs is about $1.2 million. In most cases, this is the cost to develop a cleanup program, not the actual implementation.

- o Suspended sediment in water supply reservoirs degrades the water quality and often increases the cost of treatment. Increased levels of suspended solids nearly double the treatment costs of chemicals, energy and sludge disposal. The total unit cost of treated water is typically increased by a factor of 4.

Streams and Channels

o Every 15 years, sediment is removed from Napa River at a cost of $2 million. Maintenance dredging has been proposed for Fall 1980 to remove 125,000 cubic yards from the navigation channel at a cost of $500,000.

o Sonoma County Water District estimates annual maintenance costs for cleaning its channels and stabilizing banks to be $200,000.

o The Alameda County Flood Control and Water Conservation District projects a cost of $25 million over the next 10 years to clean up 1.8 million cubic yards of accumulated sediment. This is above their annual maintenance cost of about $100,000 to clean siltation basins and channels and to repair banks.

o Novato Creek is dredged about every three years at a cost of $55,000. Marin County Flood Control District also spends $10,000 - $50,000 on erosion repairs.

o Coyote Creek was dredged in 1975 at a cost of $175,000 to remove and dispose of 25,000 cubic yards of sediment.

o The estimated cost to clean Comer Basin, receiving drainage from Calabazas Creek, is $20,000 per year.

o The East Bay Regional Park District spends about $17,300 per year for routine maintenance cleaning of sediments from channels throughout the district.

o Contra Costa County estimates that the annual cost of sediment removal is $286,000. Most of this is for sediment removal from Walnut Creek, but also includes costs for five other watersheds.

o At a typical dredging and disposal cost of $10 per cubic yard, the calculated cost for areawide removal of sediment from streams, channels, catchbasins, inlets and storm sewers would be about $35 million per year. A survey of about 20 cities and agencies in the Bay Area indicates $5 million is presently being spent annually. Much of the data on annual maintenance removal of sediment are buried in the total budget of all public works activities.

Added to the above annual maintenance costs to remove sediment from streams and channels are the following "special projects" costs which compound the economic impacts:

o Uncalculated economic losses result from flooding due to decreased stream, channel and reservoir capacities. This is aggrevated by additional runoff generated from impervious surfaces of new development. The combined reduced stream capacity and high runoff can lead to scouring of stream banks and loss of property. As an example, development in the San Ramon Valley area has resulted in the loss of land along San Ramon Creek.

- Private law suits have been filed against developers and cities for instream and other off-site property damage due to erosion and siltation. The state Attorney General filed for civil penalties against developers in Richmond in the amount of $498,000 to recover damage costs from siltation in Wildcat Creek. Homeowners along San Pedro Creek in Walnut Creek have filed claim against the city for about $100,000 to recover erosion costs.

- In an opinion issued by the Counsel to the Regional Water Quality Control Board, developers can file suit against cities for indemnification where inadequate policies and procedures to control sediment and erosion problems and inadequate enforcement of erosion control plans result in a private suit against the developer.

- Secondary costs are also associated with damage to off-site property due to storm water runoff and sediment transport from construction sites. This may be attributed to lack of erosion controls or improper design or application of control measures. This was evidenced by recent mudslides on Pamona Road in Crockett and on Cowell Road in Concord (Chan, 1980).

Bay

- In 1979, the Army Corps of Engineers dredged 5.2 million cubic yards of sediment from the Bay at a cost of $5.4 million. It is projected that higher fuel costs will raise this cost to $6.2 million in 1980.

- Total annual expenditure to dredge sediment from the Bay and its harbors is about $14 million. Local land use practices may be responsible for a portion of this cost.

- Unit costs to dredge and dispose of Bay sediments are generally less than sediment removal costs for inland waterways. This is primarily due to the large amount of sediment dredged, which reduces unit cost, and to reduce disposal costs, since almost 90% of the spoils are disposed back into the Bay.

- Fisheries heavily dependent upon nearshore aquatic productivity suffer economic losses due to habitat damage.

IV. SUMMARY

The annual sediment mass balance for the San Francisco Bay indicates 8.3 to 9.4 million cubic yards of sediment are washed from local watersheds each year. About 70% of this sediment is deposited in reservoirs, streams, channels, catchbasins, etc., creating localized impacts and cleanup costs. The remainder is washed into the Bay where it comprises 25% of the total sediment inflow.

Numerous water quality problems and associated costs arise from the transport of this sediment. Based on typical dredging costs alone, it would take $65 million to keep sediment from building up in inland waterways. Actually costs are difficult to obtain since much of the cleanup data is buried in overall public works programs. Most large scale dredging and remedial projects occur every 10-30 years and cost data must be annualized and updated. Reported annual costs to remove sediment from inland waterways is presently $7 million. More complete data is available on dredging operations in the Bay where $14 million is spent annually.

Off-site costs incurred to dredge sediment is matched by the on-site value of the soil washed away. The value of this soil can be based on the value of the lost nutrients or on the replacement topsoil. The estimated value of the soil loss from local watersheds is $60 million.

Other costs associated with erosion-related water quality problems include loss of reservoir storage capacity, flood carrying capacity of streams, damage to private and public property, increased treatment of water supplies, loss of beneficial uses, and impacts on aquatic habitat. These costs are difficult to quantify since they are often buried costs incurred to an entire district or community. This is significant when referring to costs incurred from excessive erosion from a small amount of land and paid for by the community.

Erosion rates differ dramatically among various land use practices, but to a large extent can be minimized by prudent control measures. For example, annual development occurs on 0.1% of the region's total land, yet generates 2-14% of the total sediment to the system. Even the 2% increase in sediment load can significantly impact a balanced or marginally balanced stream, stressing its ecosystem to destruction.

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WQ/Tech Memo #56/April 1980
R. Brady/L. Henze/D. Wambem

WATER QUALITY MANAGEMENT PLAN
ECONOMIC ASSESSMENT OF RECREATIONAL BENEFITS FROM WATER POLLUTION CONTROL PROGRAMS

Technical Memorandum No. 56
April 16, 1980
Revised July 15, 1980

I. INTRODUCTION

This Tech Memo presents a number of concepts for estimating usage and value of benefits generated from expansion of recreational facilities or opportunities in connection with water quality programs. It presents an overview and discussion of the major topics which should be considered in estimating recreation facility usage, and a procedure for benefit estimation which can be adapted to needs of particular projects at hand.

For a comprehensive evaluation of potential recreational benefits, the evaluation methodology should be supplemented by the most current data base for specific regions and consultation with local recreation planners.

The Nature of Recreational Benefits Stemming from Water Quality Programs

Water quality management programs can yield substantial benefits to Bay Area communities through enhancement of recreational opportunities, as well as through restoring and maintaining environmental quality and meeting health and safety standards. Increased recreational opportunities may occur as a result of upgrading the quality of existing lakes and streams to levels which can support more intensive recreational use, such as swimming, wading and other water contact sports. In addition, general improvements in the aquatic environment may provide additional wildlife habitats for nature observation, fishing, hunting and shellfishing. Expanded recreational opportunities may result from the development of hiking and riding trails along pipeline rights-of-way, and from improving public access to the Bay shoreline, wetlands and other open space areas. Lastly, construction of new wastewater treatment facilities can be combined with the development of specific recreational facilities needed within a community, such as playing fields, tennis courts or public meeting sites, through coordinated, mixed-use facility planning.

ABAG's Technical Memo 39 outlined the different kinds of recreational and open space benefits which can result from water quality management programs. This memo will discuss techniques for quantifying recreational benefits associated with proposed projects.

Economic Evaluation of Recreational Benefits

There are several reasons for performing an economic evaluation of recreational benefits which will result from water quality programs. Under ABAG's Environmental Management Plan, approximately $300 million could be spent annually for water quality management. With a program of this magnitude, comprehensive assessments of costs and benefits of projects are necessary, and potential recreational benefits are one important area of assessment. In addition, analysis of these benefits conforms with goals set forth in the 1978 Nationwide Outdoor Recreation Plan and with the Water Pollution Control Act of 1972, as amended.

More broadly, in a time of growing fiscal constraints, local officials are increasingly concerned with justifying costs of public projects. Estimation of additional economic benefits of water quality programs will provide important information to assess the overall impacts and effects of projects proposed in particular communities. In addition, direct local funding for recreational facilities is declining. Identification of recreational opportunities associated with water quality programs and estimation of their economic benefits can provide incentives to maximize the development of recreational facilities in association with water quality programs, thereby increasing efficiency and reducing costs.

Contents of the Memo

Section 2 of this memo will discuss estimation of recreational benefits. It will begin with an overview of economic evaluation concepts and techniques, present a recommended method for evaluation of recreational benefits, and discuss considerations for weighing recreational benefits against project costs. Section 3 will discuss activity demands. It will present ways to derive estimates of projected usage of proposed recreational facilities or sites, as a function of the size and nature of the surrounding population, their potential demand for recreational facilities, and the portion of this demand which is already served by existing facilities. Section 4 will discuss travel and opportunity costs. It will present a procedure to distribute the potential demand which the new facility will serve over the surrounding travel time zones and to assign dollar values to the estimated visitor-days that the proposed recreational site will generate. Section 5 will discuss procedures for carrying these estimates into the future stream of recreational benefits. Following the body of the report, appendices will present an outline of procedure to follow, an example for a hypothetical facility and tables to assist in the analysis.

II. ESTIMATING RECREATIONAL BENEFITS

Overview of Economic Evaluation Concepts and Techniques

Estimation of the economic value of recreational benefits is a two-part process which combines estimates of facility usage with estimates of the benefits each recreationist derives from the use of the facility. Recognizing that recreational facilities have a long life span, estimates of both facility usage and benefits need to be projected into the future, and discounted to establish the present value of total recreational benefits associated with a proposed expansion of recreational opportunities.

One point needs to be made clearly at the outset: public recreation areas are not private goods. The entry price is nonexistent or set low to enable wide public use. Hence, market price regulates neither the quantity of recreation demanded nor the quantity of facilities supplied, and cannot serve as a measure of the benefits people derive from activities at the site. To assess the economic value of spending a day at a public recreational facility, then, we need to introduce the concept of exchange or opportunity cost: what people are willing to give up or exchange in order to participate in a recreational activity at a recreational site.

There are a number of accepted methods for assessing and assigning values to recreational benefits in the literature on recreational benefit assessment. Among the major alternatives which are used by recreation project analysts are the unit value, travel cost and compensation value methods of benefit assessment.

Unit Value Method

The most common procedure for valuation of recreational benefits is the unit value method, recommended by a number of federal and state agencies with jurisdiction over recreational areas and projects.1/ Simply put, this method assigns a dollar value to the visit of a representative individual to the recreational facility, and multiplies this visitor-day unit value by the estimated number of users of the facility. Federal and state agencies generally specify a range of unit-day values to be used in project benefit assessment, and a matrix of criteria with a corresponding point evaluation system to determine which unit-day value within the range should be assigned to a proposed facility.

1/ The Federal Water Resources Council, the U.S. Army Corps of Engineers, the Bureau of Outdoor Recreation, the Pacific Southwest Inter-Agency Committee and the California Department of Parks and Recreation all utilize the visitor-day unit value method. For a fairly comprehensive report on the visitor-day unit value method of benefit assessment, see Dr. Morgan Johnson, Valuation of Outdoor Recreation Benefits, report prepared for Santa Clara Valley Water District, October 1978.

The most recent estimates of the valuation of a recreation-day by the Federal Water Resource Council sets the recreation-day unit value range at $1.07 to $3.20 for general recreational activities and at $7.50 to $12.87 for specialized recreational activities in 1979. The California Department of Parks and Recreation and Department of Navigation and Ocean Development planning manuals recommend a recreation-day unit value range of $.50 to $2.50 for general recreational activities and $2.00 to $6.00 for specialized recreation activities.2/ Many subsequent studies simply update these ranges to the present by adjusting them for changes in the relevant segments of the Consumer Price Index. The unit day value range is a product more of convention than actual analysis, and its primary usage is for comparison among alternative projects rather than assigning accurate absolute values to recreational benefits.

Travel Cost Method

A method of recreational benefit assessment based on the travel costs incurred to reach a recreational area has achieved wide acceptance in the literature on the economics of benefit assessment.3/

When examining the individual and aggregate behavior of households, the time and money costs incurred in getting to a recreational site can be reviewed as a proxy for price which regulates the quantity of recreation demanded. It has been amply demonstrated that recreational facilities draw more heavily from nearby zones of population. User demand decreases as a function of increasing distance, increasing time and travel costs and the greater likelihood of proximity to substitute facilities. Hence, a demand curve for recreational activities can be constructed as a function of travel costs by measuring how participation in recreational activities varies with distance or travel time to the site, and determining the appropriate travel cost/distance factor. From such a demand curve, the concept of consumers' surplus can be used to measure the benefits associated with construction of an additional recreational facility.

2/ See State of California, Department of Parks and Recreation, "Water Project Recreation Planning Manual," March 1967, and State of California, Department of Navigation and Ocean Development, "Guidelines for Evaluation of Economic Justification and Financial Feasibility of Projects," April 1971.

3/ See, for example, N.W. Mansfield, "The Estimation of Benefits from Recreation Sites and the Provision of a New Recreation Facility," in Arnold C. Harberger et. al., Cost Benefit Analysis, Aldine-Atherton Inc., 1972; V. Kerry Smith, "The Estimation and Use of Models of the Demand for Outdoor Recreation," EGI Working Paper No. 3-75, prepared for the National Research Council of the National Academy of Sciences, March 1975; and Charles R. Lewis, IV, "Benefit-Cost Analysis of a Proposed Boat Launching Facility at Mossdale Y, San Joaquin County, California," prepared for San Joaquin County Department of Parks and Recreation, 1975.

Compensation Method

A quite different approach to the valuation of recreational benefits has been based on a welfare economics framework as opposed to a willingness to pay framework, using a compensation method.4/

Under the precepts of welfare economics, any reallocation of society's resources will represent an improvement over the status quo if the gainers from the reallocation would be able to compensate the losers. In theory, everyone could then be made better off as a result of the reallocation. Some economists have argued that rather than focussing on willingness to pay to serve as a measure of benefits, recreation analysts should focus on a compensation approach, particularly when the question at hand is the impact of a loss rather than expansion of recreational facilities. In this method, individuals are queried about their willingness to forego or sell their rights to use a recreational facility. The resulting number of persons willing to forego or sell their rights to participate at a facility at a series of specified prices can be used to construct what is called an offer curve. The different compensation values reported can then be multiplied by the number of individuals specifying that value to obtain a total benefit figure. Individuals are not bound by an income constraint under this approach. Rather than measuring the direct economic value of benefits to be fated forgone resulting from loss of a recreational area, this method may provide a proxy for non-economic benefits.

User Cost and Consumer Surplus Method

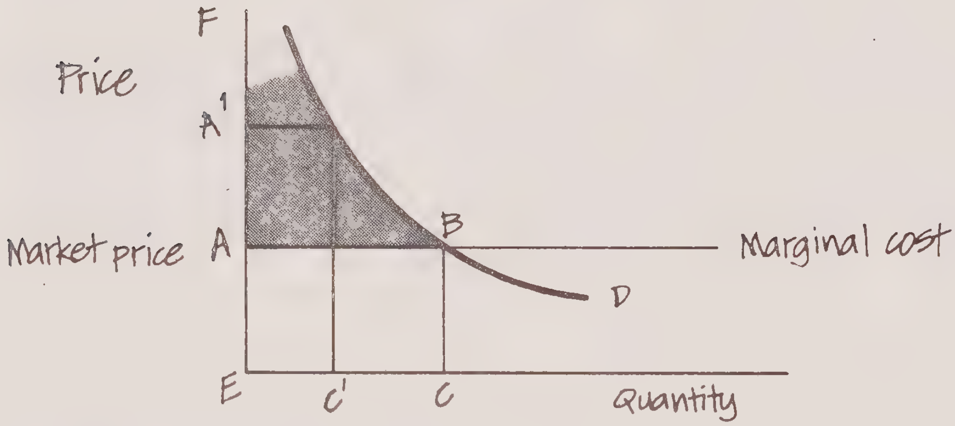
While each of the above methods is in accepted use, we argue that for the purposes of this analysis, a sound method of recreational benefit assessment can be obtained by a method combining user costs and consumer surplus. This is essentially an elaboration of the travel cost method. Two major points should be noted. First, the user cost concept expands on the travel costs concept by recognizing that costs incurred to participate in a recreational activity include not only transportation costs, but the opportunity cost of time spent in travel, and an activity cost comprised of entrance fees and any equipment costs on a per trip basis. Second, this method recognizes that the actual costs incurred by an individual recreationist are not a full measure of his or her total benefits derived from participation in the activity. Actual costs incurred do not capture the recreationist's "consumer surplus," which are the extra benefits derived from all trips but the last. According to standard microeconomic consumer theory, it is only for the last trip taken each year that marginal benefits will equal rather than exceed marginal cost, as discussed below.

4/ The compensation method of recreational benefit assessment has been proposed by Philip A. Meyer in three recent articles: "Publicly Vested Values for Fish and Wildlife: Criteria in Economic Welfare and Interface with the Law," Land Economics 55:2 May 1979; U.S. Fish and Wildlife Service, The Value of Fish and Wildlife of San Francisco Bay - A Preliminary Survey, August 1979; and California Water Policy Center, "Recreational Fishing Values at Risk: Recent Developments in Compensatory Methodology in the United States and Canada," April 1980.

Consumer Surplus

According to the precepts of microeconomics, an individual facing market price p^* will consume q^* units of a good, satisfying the first-order equilibrium condition of utility maximization that marginal cost or price, equals marginal benefit derived from consumption of a good. Total benefits to the individual include more than just the marginal benefit, proxied by p^*, times the number of units consumed, q^*, however. This is illustrated in Figure 1.

FIGURE 1



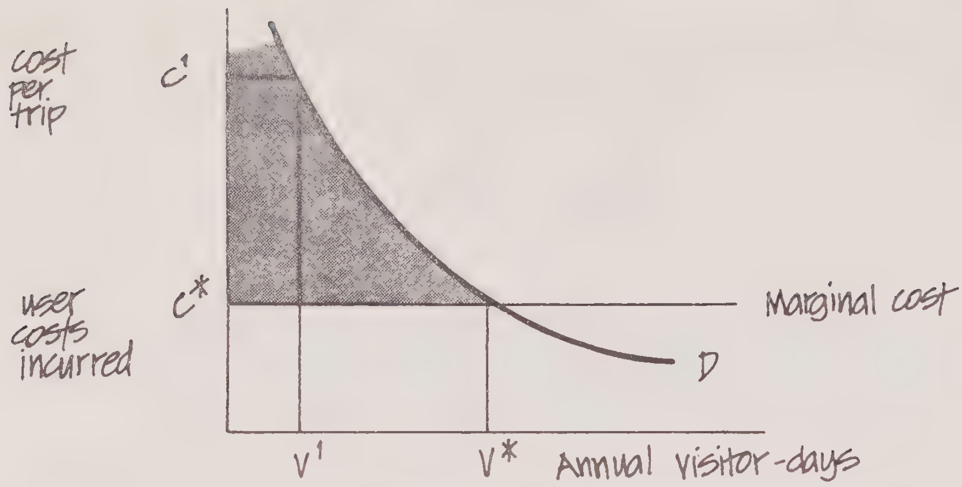
For each unit of the commodity less than q^*, say q', the consumer was willing to pay p' is greater than p^*. The concept of consumer surplus measures the benefits to the individual reflecting the difference between what is actually paid and what he or she would be willing to pay for each unit of the good. Consumer surplus is represented by the shaded area under the curve, ABE, which is the area under the integral, $\int_0^{q^*} D$, minus total revenues paid by the consumer, ABCD:

$$\text{Consumer Surplus} = \int_0^{q^*} D - ABCDE$$

Extension to Recreational Benefit Analysis

The concept of consumer surplus holds for recreational benefit analysis as well. Recreationists will participate in recreation activities until the marginal benefits derived from the last visitor-day, v^*, just equal the marginal costs incurred, c^*. For each visitor-day v' less than v^*, the recreationist was willing to incur costs of c', where c' is greater than c^*. This is illustrated in Figure 2.

FIGURE 2



The consumer surplus gained by the recreationist is again represented by the shaded area under the curve. Recreationists living closest to the facility will incur the lowest transportation and opportunity costs and hence the lowest user costs. Ceteris paribus, they will enjoy greater consumer surplus than recreationists living further away from the facility.

A full measure of the value of benefits to a recreationist resulting from a visitor-day spent at a given facility will include both the benefits proxied by the user costs incurred in participation, and the consumer surplus which the recreationist enjoys.

Weighing Recreational Benefits and Costs

To decide whether construction of a recreational facility is justified, total benefits generated over the future life of the facility must be compared to total costs amortized over the life of the facility. If an expansion of recreational opportunities is to represent a productive use of society's resources, the present value of expected total benefits generated must be greater than or equal to the discounted value of expected total costs.

Total benefits include both benefits to recreationists proxied by the actual costs they incur, and consumer surplus. Total costs include both actual costs incurred by recreationists in getting to and using the facility, and project construction, maintenance and operating costs. These relationships can be represented:

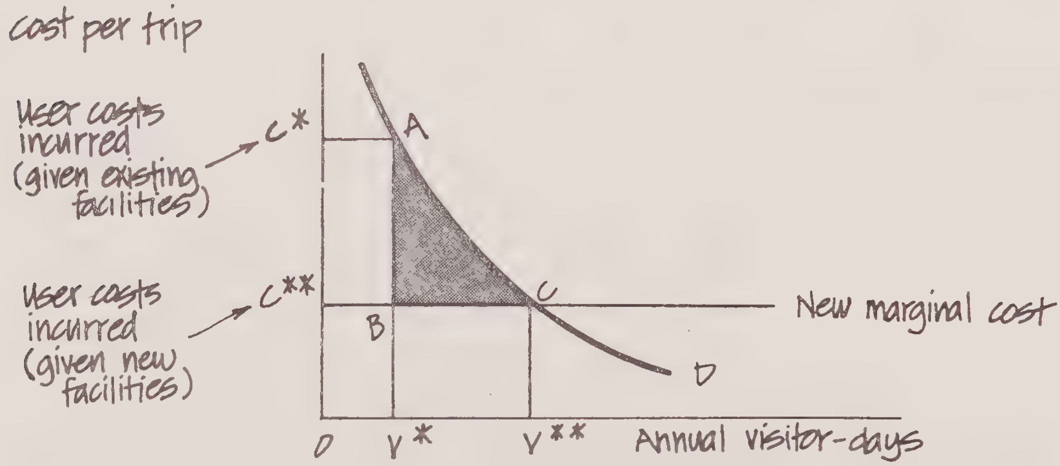
$$TB = CI + CS \tag{1}$$
$$TC = CI + PC$$

Where: TB = total benefits
TC = total costs
CI = benefits proxied by costs incurred
CI = actual costs incurred
CS = consumer surplus
PC = project construction, maintenance and operating costs

As benefits proxied by costs incurred equal costs actually incurred by definition, the condition that total benefits should equal or exceed total costs implies that consumer surplus should equal or exceed project costs if a particular recreational project should be built.

Many projects considered will represent a proposed expansion of recreational opportunities of a given type rather than creation of a new type of recreational opportunity for an area. This factor must be recognized and included in the analysis. Construction of an additional facility is assumed to lower the cost per trip for some population of users, as a facility closer to home will result in lower transportation and opportunity costs and hence lower user costs per trip. To decide whether a proposed expansion of recreational facilities should be built, one weights the net gain in consumer surplus against the project construction, maintenance and operating costs, as illustrated in Figure 3.

FIGURE 3



The increase is consumer surplus gained by construction of the additional facility is represented by the shaded area under the curve, ABEF. This increase, calculated for the recreationists from each time zone, projected into the future over the estimated facility life, and discounted to the present, must be compared to the discounted value of expected project construction, maintenance and operating costs, to assess the desirability of a proposed recreational project.

III. ESTIMATING RECREATIONAL SITE USAGE

Estimation of recreational site usage is a lengthy process, involving numerous steps. Key factors influencing usage include the size of the population surrounding the proposed site, the recreation demand characteristics of that population, the demand satisfied by existing recreational sites, the accessibility of the proposed site to the surrounding population and the probability that persons in the surrounding area will visit the proposed site. The problem of estimating current demand is compounded when usage estimates must be carried into the future for the presumed life of the facility. In this section, a methodology is presented to a discussion of estimate current conditions. A subsequent section of this Tech Memo will discuss general approaches for providing estimates for future years for all components of the analysis--site usage and visitor-day valuation.

The emphasis of this discussion is on methods which have been derived from the general literature of recreation economics and recreation travel. While general data sources are described, it is recommended that where available, data from local sources, such as city and county parks and recreation departments, planning departments and public works departments be used.

The State of California Department of Parks and Recreation has developed a comprehensive information system known as PARIS (Park and Recreation Information System), which provides estimates of recreation demand and information on the supply of recreational facilities for Bay Area counties and for the Bay Area as a whole. The PARIS system provides a source of ready information which can be utilized for planning purposes, especially when locally generated information is not available.5/

Before any estimates of recreational facility potential usage are made, the analyst should first ascertain the local situation for the particular recreational activity under consideration. If, for example, there is a surplus of facilities locally, there can be no net increase in visitor days stemming from the proposed facility, and hence, no additional recreational benefits. This would conclude the analysis as far as the proposed facility is concerned. In the more likely situation where there is a shortage of facilities for the type of recreation activity proposed, the steps to follow to estimate facility usage are described below.

5/ The User's Guide to PARIS, published by the State Department of Parks and Recreation in August 1978, provides an introduction and overview of the PARIS system. The User's Guide and detailed information from the data base can be obtained from California Department of Parks and Recreation, Statewide Planning Section, P. O. Box 2390, Sacramento, California 95811.

Defining the Area to be Served

The area to be served by the proposed facility should be defined according to a set of "travel time cohorts," that is, a grouping of surrounding communities according to the travel time required to reach the site by auto under non-peak hour highway or road conditions. An example of these travel times, which are available for the Bay Area from ABAG, is provided in the Appendix. The area surrounding the proposed facility should be defined according to "zones" based on travel time. For example, areas may be defined for travel times of less than 15 minutes, from 15 to 30 minutes, 30 to 60 minutes and 60 to 120 minutes. This grouping is made because a recreational site's "drawing power" decreases as the time required to reach the site increases. Not only is the "disutility" in terms of travel costs and travel time greater for a longer trip, but there is also a greater likelihood that an alternative and more accessible recreational site exists for the more distant populations. The travel time cohorts constitute the basic market areas from a recreational facility's usage is estimated.

Estimating the Population in the Surrounding Areas

After defining the communities in the various travel time cohorts, it is necessary to estimate the population residing in these areas. In the absence of current census data or local estimates, there are two potential sources of population estimates. First, the California Department of Finance Population Research Unit provides annual estimates of population for cities, unincorporated areas and counties. Second, population estimates are available for ABAG's 440 zones6/ covering the nine Bay Area counties. These estimates attempt to incorporate the latest local estimates, as well as data from the Department of Finance. Illustrative ABAG population estimates and projections for 440 zones are shown in Table C-2 in the Appendix.

Estimating the Total Potential Usage of Surrounding Population

The next step is to estimate the total number of annual visitor-days of the proposed recreational activity which is demanded by the population surrounding the proposed facility. Total annual visitor-day estimates should be provided for the population residing in each of the surrounding travel time cohorts.

In the absence of local data on recreation demand, estimates of potential usage are available through the State Department of Parks and Recreation PARIS data base.

6/ ABAG 440 zones are traffic analysis zones in which the San Francisco Bay Region is divided. Each zone contains population and housing information, and is the smallest geographical area used for forecasting.

PARIS provides estimates of potential demand for a variety of recreational activities. Table 1 shows the potential Bay Area demand on a per capita annual basis for a variety of recreational activities for 1970, 1980 and 1990. PARIS' estimates of per capita annual recreation demand are based on applying information on participation rates in various recreation activities by socioeconomic characteristics from a 1960-61 survey to the estimated population and socioeconomic characteristics of the Bay Area in 1970, 1980 and 1990. Updated recreation participation surveys are currently being conducted and will provide the basis for revised per capita demand estimates which will be available in 1981 or 1982. These per capita figures should be applied to the population estimates in the various travel time cohorts to estimate the annual average potential demand within the service area for a particular recreational activity, according to the formula:

$$\text{Annual Average Potential Demand} = \sum_i (\text{Per Capita Annual Demand in Visitor Days} \times \text{Population}_i) \qquad (2)$$

where i = each travel time cohort

Estimating the Unmet Recreation Demand of the Surrounding Population

The potential average usage estimates derived in Table 1 include the demand which is already met by existing facilities. This portion of the fulfilled demand must be subtracted from the total potential usage to arrive at an estimate of unmet demand, which serves as the "market" from which to estimate a proposed recreational facility's usage. Once again, when possible, it is preferable to use data from local parks and recreation departments. If local data are not available, the PARIS system can be utilized to collect information on the existing supply of recreational facilities in the service area, or to derive proxy measures of unmet demand on a county basis.

The PARIS system provides detailed reports on the inventory of outdoor recreational areas and facilities by recreation site, by county and by other geographic areas. By requesting reports for recreational facility sites within the service area, the planner will be able to subtract the portion of potential recreation demand that is served by existing recreational facilities to estimate the unmet recreation demand of the surrounding or proposed facility.

Another approach may be utilized as well. The PARIS system provides information by county on needed recreational facilities, existing facilities available and the resultant shortage or surplus of recreational facilities for four facility types: camping units, picnic tables, boat access sites and miles of trail. As these are estimates for facilities and not for unmet demand for recreation visitor-days of various types, they need to be adjusted to estimate the proportion of potential demand which is unmet. Thus,

$$\text{UNMET DEMAND} = \text{Potential Usage} \times \left(1 - \frac{\text{Existing Facilities}}{\text{Needed Facilities}}\right) \qquad (3)$$

Therefore potential usage is determined as in the previous section and the ratio of existing facilities to needed facilities is taken from the PARIS data.

We see from this equation that if the existing facilities are equal to the facilities needed, then the factor subtracted from potential usage is zero and there is no unmet demand. If, on the other hand, there are no existing facilities, then the factor subtracted from potential usage is 1.0 and all potential demand is unmet. Where there is no PARIS estimate for the activity in question, either the most closely related activity available from the PARIS system or other estimates must be used.

Table 2 presents estimates for 1980 of ratios of existing to needed recreation facilities derived from the PARIS system.7/ In most counties, and for most recreational facilities, a substantial shortage is shown. However, surpluses of most facilities are indicated in Napa County, and boat access sites are in surplus in most parts of the region. Of the four recreational facility types shown, the greatest shortages exist for trails.

Supply Capacity and Peak Demand

There are two final considerations before recreation site usage can be estimated. The first relates to the supply capacity of the proposed facility. Capacity must be considered as a ceiling of estimated usage. Estimates of capacity should be based on existing usage of recreational facilities and expressed as visitor-days per year. Daily capacity figures for four facility types are available from the PARIS system and are summarized below in Table 3.

TABLE 3

Use Standards for Selected Recreational Facilities
(Persons per Day)

Facility Type	Use Standard
Camping Units	3.5 persons
Picnicking Units	4.0 persons
Boat access sites	4.2 persons per slip or mooring
Miles of trail	20.0 persons per mile of hiking trail
	10.0 persons per mile of riding trail

SOURCE: State of California, Department of Parks and Recreation, The User's Guide to PARIS.

7/ These figures are based on the existing supply of facilities and projections of demand made in 1973. More recent estimates will be available in State Department of Parks and Recreation, Recreation Outlook in Planning District 4, forthcoming in May 1980.

The second consideration relates to peak demand, as opposed to annual demand which has been previously considered. Recreation demand shows greater concentrations on weekends, holidays and during summer months. The severity of recreational facility shortages during these periods should be considered in addition to overall shortages. The PARIS system uses the following formula to estimate peak daily use:

$$\text{Peak Daily Use} = \text{Peak Daily Use Factor} \times \text{Summer Use Factor} \times \text{Annual Demand in Visitor Days} \qquad (4)$$

For day use activities, the peak daily use factor is .01; while for overnight activities it is .015. Summer use factors for selected activities are shown in Table 4.

Consideration of peak demand is important because there may be shortages during peak periods even though facilities appear adequate to serve annual demand. In these situations, a facility should be evaluated on the basis of visitor-days during peak demand periods. It is therefore recommended that if peak demand is critical in determining Total Annual Demand the following process be taken:

a) Estimate annual average potential demand;

b) Divide number of days per year to obtain average daily demand;

c) Estimate peak daily demand by:

   1) Average annual visitor-days/yr x daily peak factor x ratio of existing to needed facilities for target year = peak daily demand.

d) Estimate number of days of peak and non-peak.

e) Estimate total potential demand by:

   1) Non-peak days x average daily demand (visitor-days) x peak days x peak daily demand (visitor-days) = Total Potential Demand.

TABLE 1

Annual Potential Demand for Recreational Activities
San Francisco Bay Area
(Visitor-Days Per Person)

Activity	1970	1980	1990
Picnicking	5.1	5.6	6.3
Walking, nature observation	23.8	26.4	29.3
Jogging	n.a.	n.a.	n.a.
Bicycling	8.6	9.5	10.6
Horseback riding	1.3	1.5	1.6
Roller skating	n.a.	n.a.	n.a.
Outdoor games and sports	24.2	26.8	29.8
Meeting area use	n.a.	n.a.	n.a.
Hiking	1.9	2.1	2.3
Camping	2.4	2.7	3.0
Fishing	3.0	3.3	3.7
Swimming and sunbathing	16.2	17.9	20.0
Small boating	4.4	4.9	5.4
Golfing	n.a.	n.a.	n.a.

n.a. = not available

SOURCE: Calculated from State of California, Department of Parks and Recreation, PARIS system.

TABLE 2

Ratio of Existing to Needed Recreational Facilities
San Francisco Bay Area, 1980

County/ Facility Type	Camping Units	Picnic Tables	Boat Access Sites	Miles of Trail
Alameda	0.34	0.48	1.54	0.22
Contra Costa	0.05	1.92	1.62	0.51
Marin	0.13	0.16	1.26	0.32
Napa	5.42	3.19	3.30	0.29
San Francisco	0.00	0.14	2.40	0.00
San Mateo	0.20	0.60	1.21	0.22
Santa Clara	0.10	1.05	0.33	0.15
Solano	0.14	0.58	0.84	0.00
Sonoma	0.67	0.33	0.30	0.36
Weighted Regional Average	0.51	0.76	1.18	0.25

SOURCE: Calculated from State of California, Department of Parks and Recreation PARIS system.

TABLE 4

Proportion of Total Participation in Selected Recreational Activities During Summer Months (June, July and August)

Activity	Proportion
Picnicking	.485
Walking, nature observation	.235
Jogging	n.a.
Bicycling	.395
Horseback riding	.446
Roller skating	n.a.
Outdoor games and sports	.233
Meeting area use	n.a.
Hiking	.683
Camping	.522
Fishing	.478
Swimming and sunbathing	.702
Small boating	.588
Golfing	n.a.

SOURCE: Calculated from State of California, Department of Parks and Recreation PARIS System

IV. METHODOLOGY USED TO DISTRIBUTE TOTAL USER DEMAND OVER TIME ZONES AND CALCULATE THE TOTAL VALUE OF RECREATIONAL BENEFITS GENERATED BY THE PROPOSED FACILITY

In Section 2, our discussion focuses on methods used to estimate total potential demand in visitor-days for activities. This section will develop a methodology to distribute the annual visitor-days estimated for a recreational facility over the surrounding population as a function of the time required to reach the facility. Data generated in the construction of this distributional matrix will also be used to estimate the value of recreational benefits per visitor-day that will be generated by the new facility.

Calculating Costs Associated with Recreation

The distribution of user demand and the value of recreational benefits will be estimated as a function of the travel, activity and opportunity costs which individuals incur in participating in a recreational activity.

Travel Costs

Costs incurred in travel to a recreational area are a major element entering the proxy-for-price variable. Measures of travel costs used are generally the marginal cost of travel which will include either the marginal cost of vehicle operation (primarily gasoline) or the cost of public transit to the facility. Travel costs need to be computed on a round trip basis and need to be standardized per visitor, taking into account the average number of recreationists per vehicle.

Activity Costs

Activity costs are comprised of user or entrance fees and any equipment costs. While entrance to many public recreational facilities is often nominally priced or free, entry price should be included as an element of what the recreationist will exchange in order to participate in the activity. Entry or membership fees are generally a more substantial element of the cost of participating at private recreational facilities. However, increasing revenue constraints faced by state, local and regional governments and agencies will exert increasing pressure on entrance or user fees of public recreational facilities in the future.

Many recreational activities, from fishing and camping to baseball and tennis, require purchase or rental of large or small items of equipment. The need for substantial outlays for some recreational activities such as boating or water-skiing helps stratify demand for these activities as a function of income. Recreation equipment costs have generally been

excluded from the proxy-for-price variable on the grounds that, once purchased, the marginal cost of using the equipment is nominal. However, an alternative approach would include the cost of equipment used on a per trip basis in the measure of what persons are willing to give up or exchange to participate in recreation activities. Given difficulties in standardizing purchase prices over time and in estimating equipment usage, these costs can be approximated by the day rental cost of major items of equipment, and omitted for minor items such as baseball gloves and frisbees.

Opportunity Costs

Recreation is defined as activities which are engaged in during leisure time. One factor which differentiates recreational activity from consumption of other goods and services is that large periods of time are expended in recreation "consumption." While individuals are not paid to engage in recreation, they are choosing to spend time in a particular activity that might have been spent in another form of activity: in additional or overtime work, in household and personal maintenance (such as housework, home and yard maintenance, cooking, trips to the cleaners and the bank, and shopping for household and personal items), or in other forms of recreational activity. We recommend that recreation planners incorporate the opportunity cost of time spent in travel in getting to a recreational site as an element of the value recreationists assign to participation in that activity. A median prevailing wage rate can be used, and the opportunity cost measure should be standardized for the number of persons per trip assessed to be engaging in the opportunity cost trade-off.

These costs, hence, comprise the foundation to distribute potential visitor-days over the surrounding population. Consumer surplus values are calculated, directly from the distribution, generating the potential benefits resulting from increased recreational activities.

Calculating Travel Time and Distance Zones

An essential first step in distributing the potential visitor-days that will be served by the new facility over the surrounding population is to establish a relationship between travel time and distance. Table 5 presents an illustration of this relationship. Each time-distance zone will exhibit specific potential visitor-day demands.

Questions which the recreational planner should address in constructing such a table include:

a) Given the proposed facility, what is the estimated maximum distance that a user would travel to use the facility?

b) What is the minumum average time that the closest user would have to travel to reach the facility?

c) What are the associated times of the identified distances?

TABLE 5

Hypothetical Relationship Between Travel Time and Distance in the San Francisco Bay Region

Zone	Minutes Required*	Distance Traveled (In Miles)
1	15	4
2	30	8
3	45	14
4	60	21
5	75	31
6	90	42
7	105	55
8	120	70

*Time to travel, park and unload vehicle.

Hence, two critical information pieces are: a) minimum travel time with corresponding distance, and b) maximum travel time with corresponding distance. With these data, the planner should develop a distribution of concentric travel time zones radiating out from the proposed facility.

Estimating the Demand for Recreational Sites as a Function of Costs Associated with an Activity

In this section, we develop a probabilistic demand distribution function to distribute the demand for the recreatinal activity that would be generated by public investment at a proposed site. This distribution process is a function of the following:

a) the total number of potential visitor-days that would be generated by the proposed facility;

b) the costs to visit the site and the cost of the activity;

c) rise in the price of gasoline relative to the change in personal income per capita in constant base year dollars, and;

d) the relative income per capita of each zone to the mean income per capita for the study area.

The demand distribution equation is defined as:

$$D(p) = e^{-k(pi)^{a}} \qquad (5)$$

where: D(p) = the coefficient of demand.

k = a constant determined by the relationship, (1/(ln visitor-days)(ln (IN/IM)) (X). (6)

P_i = the cost associated with each zone of travel (Tc_i + Oc_i + Ac).

a = (Area per capita income/zone per capita income) This coefficient is used to adjust (pi) value by zone. It expresses the relative importance of a zones income to the study area's income in determining demand by zone for a recreational activity at a site.

IN = Tc+ Oc +Ac for the zone closest to the facility.

IM = Tc+ Oc +Ac for the zone furthest from the faciliy.

X = (1-sin(1/g)) + (cos (1+Yp)); (7)

where:

g = Price increase in the cost of gasoline in constant base year dollars.

Yp = Real growth in personal income per capita over base year.

Tc = transportation costs, expressed as follows:

Tc = (Pg/Mg) (d) (Pv). (8)

where:

Pg = price of gasoline ($/gallon).

Mg = miles/gallon for auto.

d = round trip distance from origin to recreational destination (miles)

Pv = persons per vehicle.

Oc = opportunity costs, expressed as follows:

Oc = round trip time in minutes to recreational area x N x (mean prevailing wage rate per hour in region or demand area)/60 minutes,

where:

N = a deflator of mean wage rate as a measure of opportunity cost

Ac = activity costs which consist of user fees and cost of equipment on a per trip, per user basis.

The coefficients derived in Equation (5) are now normalized to obtain a percentage distribution of demand that would occur if all zone populations were equal over the entire study area. Hence, the normalized coefficient is expressed as:

$$ND(p)_i = D(p)_i / \sum_{L}^{N} D(p)_i \text{ for all zones.} \qquad (9)$$

Hence, equation (9) provides a coefficient distribution of demand as a function of travel time. This coefficient can be multiplied by the population residing in each travel time zone to obtain the potential demand for the facility from the recreationist in each time zone:

$$D(z)_i = ND(p)_i \times Zp \qquad (10)$$

where:

$D(z)_i$ = potential demand from each time zone i

$ND(p)_i$ = normalized coefficient of demand for zone i

Zp_i = Population in zone i

To adjust for the constraint that actual demand served by the facility cannot exceed its supply capacity, the following calculation is undertaken:

$$V_i = C \times Pc_i \qquad (11)$$

where:

$Pc_i = D(z)_i / \sum_i D(z)_i$

V_i = actual visitor-days served from time zone i

C = visitor-day capacity (or total visitor-days actually supplied) by the new facility

Pc = conditional probability for zone i

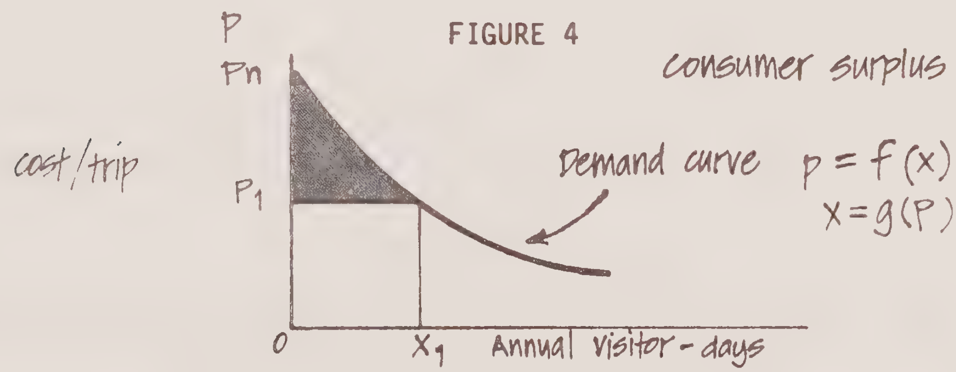
By this method, we have arrived at a procedure for estimating the demand for recreational activities at a proposed site by the population residing in the surrounding area. Next, we will formalize the method to assign values to the recreational benefits enjoyed as a result of expansion of recreational opportunities.

Assigning Value to Visitor-Day Demand

Recognizing the difficulties of assigning value to recreational benefits, we have taken the position that the potential stream of benefits generated are equal to the sum of the total costs associated with participation in the activity (i.e., transportation, opportunity and activity costs), plus the consumer surplus associated with each travel time zone. The concept of consumer surplus, discussed earlier in this memo, measures the value of the resouce or activity to the consumer over and above the price he or she pays for all but the last unit consumed.

Earlier, we measured consumer surplus as the integral over quantity of the area under the demand curve, net of costs actually incurred in participating in the recreation activity. Alternatively, consumer surplus can be measured as the integral over price of the area under the demand curve, with the relevant price boundaries chosen to exclude actual user costs incurred. To illustrate,

FIGURE 4



$$\text{Consumer Surplus} = \int_0^x f(x)dx - p_1 x_1 = \int_{P_1}^{Pn} g(p)dp$$

where:

$x = g(p)$ and Pn is the value of p when $x = 0$

Because of the possibility that each concentric ring around the recreation site may have different population sizes, the process of calculating consumer surplus requires steps that might not be necessary if the population were equally distributed throughout the study area. The first step necessary to calculate consumer surplus is to integrate equation (5) which generates the demand coefficient. That is,

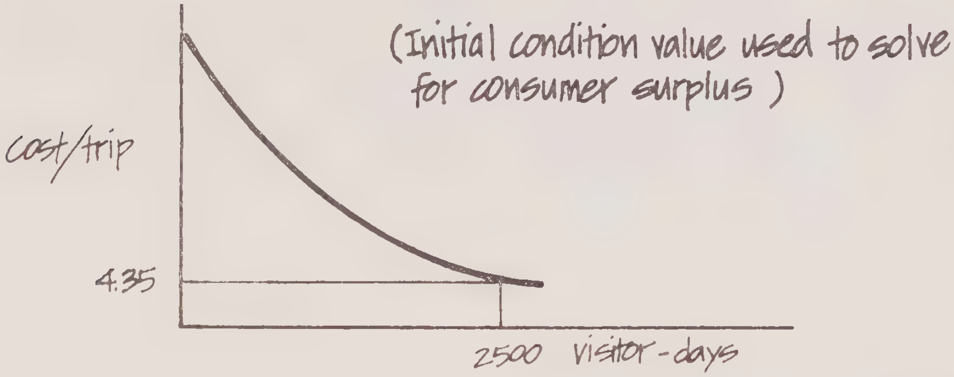
$D(p) = e - k[(p^1)^a], \text{ let } a = 1 \text{ and } (P_1^{\,a}) = po$

We integrate equation (5),

$$CS_o = \int_{P_1}^{Pn} e^{-kpo}\, dp = \left[-1/k\; e^{-kpo}\right]_{P_1}^{Pn} \qquad (12)$$

Now, we include an additional value at this stage which is defined as the floor value of user costs from the closest in zone. This value establishes an initial point to integrate the remaining area under the demand curve. Figure 5 identifies the condition.

FIGURE 5



Now, let Co = minimum cost/trip x total potential visitor-days

Therefore, Equation (12) becomes,

$$CS_o = \int_{P_1}^{Pn} C_o^{\;-kpo}\, dp = C_o \int_{P_1}^{Pn} e^{-kpo}\, dp \qquad (13)$$

$$CS_o = \int_{P_1}^{Pn} C_o \left[-1/k\; e^{-kpo}\right]_{P_1}^{Pn}$$

Now,

$$CS_o = -\frac{Co}{k}\left[e^{-kpo}\right]_{P_1}^{Pn}$$

$$CS_o = \frac{Co}{k}\left[e^{-kpo} - e^{kpn}\right]$$

If Po = 0, then $CS_o = \frac{Co}{k}(1 - e^{-kpn})$

Now, Cs_o is the Consumer Surplus associated with zone i for a given cost (price) associated with the distance and willingness to participate in the proposed recreational facility at a site. Unfortunately, this value

does not take into consideration that varying population between zones affects the total value of consumer surplus. A zone next to the recreational site may have no population, but because of it's proximity, the methodology would assign a large consumer surplus value to the zone. To adjust for variations in population size among zones, an additional step is added to the computational process. We multiply the normalized coefficient of demand (found in equation (9)) by the total potential demand to obtain the theoretical demand if all zones had equal populations. This demand (expressed in visitor-days by zone) is divided into the consumer surplus value (CS_0) assocated with the zone to obtain a per visitor-day value associated with the zone. After performing the operations found in equation (10) which weights the demand coefficient by the zone population, we obtain a weighted measure of demand by zone. This variable is multiplied by the total potential demand or visitor-day capacity (c) to obtain the demand by zone. Now that we have estimated demand by zone and the per visitor-day values associated with the zone, we multiply the two variables to obtain the consumer surplus (CS_0) associated with the population in each travel time zone.

For example, for Zone 1, (Base Year Estimate)

Let;

Total cost to recreational site = \$4.35
Furthest zone costs to recreational site = \$22.88
Total calculated potential demand = 2500 visitor-days/year.

Now,

$$k = (1/\ln 2500)\ (\ln 4.35/22.88)$$

$$= (1278)\ (-1.66.008)\ (-)$$

$$k = .212159$$

Theoretical consumer surplus (CS_0) for zone 1:

$$\int_{4.35}^{22.88} (2500/.212159)\ (e^{-2121(4.35)} - e^{-.2121(22.88)})$$

$$\int_{4.35}^{22.88} 51258\ (e^{-0.922635} - e^{-4.852})$$

$$\int_{4.35}^{22.88} 51258\ (.389657) \simeq \$19,973$$

Now, the value \$19,973 represents the initial consumer surplus associated with zone 1. Implicit in this value is the assumption that population between each zone is uniform. Clearly, it is quite unlikely that travel time zones ar ound a recreational site will have uniform

population densities. This assumes uniform housing density and development patterns -- both of which are an anomaly in most urban settings.

Hence, given the initial value of consumer surplus (CS_0), we now calculate the remaining steps to determine the consumer surplus (CS_0) associated with the zone population.

Let the coefficient 0.4122 equal the normalized demand coefficicint associated with zone 1. If all zones are uniform in terms of population density, then the demand for zone 1 is equal to 0.4122 x 2500 = 1031. However, the zones are not uniform and therefore a weighted distribution must be calculated which affects the visitor-day distribution for zone 1. Since we are concerned with calculating the consummer surplus (CS_0) for the zone, the first step is to divide $19,973/1031 = $19.37/visitor day. Now, the normalized demand coefficient is multiplied by the population of each zone to obtain a weighted distribution. The sum of all weighted populaton distribution is divided into each zone weighted population to attain the probability of demand with respect to zone population. For zone 1, this value (Pc_0) is equal to .4569. The value (Pc) is multiplied by total visitor - days (V) to obtain (pZp), In this case, .4569 x 2500 = 1142 or the estimate of visitor - days generated from zone 1. The value 1142 is multiplied by $19.37 to obtain the consumer surplus (CS_i) for zone 1 which is equal to $22,210. This process is repeated for all zones where there is an initial consumer surplus (CS_0) value, until the actual consumer surplus (CS_i) associated with the visitor-day potential are calculated.

After calculating the consumer surplus for each zone, they must be added to obtain the consumer surplus associated with the potential demand for the facility in each period. That is,

$$CS = \sum_{i=1}^{n} CS_i \qquad (14)$$

Finally, it is necessary to calculate the benefits associated with the actual costs incurred for the potential trips generaed by the recreational facility. Implicit in this concept is the asumption that the cost associated with travel and entrance into the recreation facility are benefits that the user equates with using the facility. To obtain the benefits assoiated with user costs incurred, multiply the price of using the facility at a recreational site for each zone by the potential demand calculated previously by zone. That is,

$$CI_i = (Tc_i + Ac + Oc_i)\ (\text{visitor-days}_i\ ) \qquad (15)$$

Since the individual zone benefits proxied by costs incurred (CIi) to obtain the total benefits for all zones associated with the usage of the facility. Hence,

$$CI = \sum_{i=1}^{n} CI_i \qquad (16)$$

To obtain the total benefits generated by construction of the recreational facility in year n, we add total consumer surplus and total

benefits proxied by costs actually incurred:

$$\text{Total Benefits}_N = CS_N + CI_N \tag{17}$$

This concludes the section of this paper in which user demand and total recreational benefits are calculated. As discussed at the end of Section II, construction of a proposed recreational facility equal or exceed total costs of the facility and costs to individual users, which is equivalent to the condition that total consumer surplus generated over the facility life equal or exceed projected construction, maintenance and operating costs.

V. CALCULATING FUTURE DEMAND, VISITOR-DAY VALUES, AND THE PRESENT VALUE OF RECREATIONAL BENEFITS

It is apparent that decisions on any policy need be made in the presence of uncertainty surrounding the future streams of costs and benefits. This uncertainty is derived from imperfect knowledge about future economic and social conditions that would affect consumer tastes, price changes and growth in the economy.

Future Usage and Visitor-Day Value Estimates

Both visitor-day values and facility usage estimates need to be projected for future periods over the estimated life of the recreational facility. We have derived a simple methodology which permits charges in visitor-day values to reflect changes in such factors as gasoline costs, activity costs and opportunity costs of time spend in travel. Estimates of facility usage may need to be adjusted to reflect anticipated changes in population, socioeconomic characteristics or availability of substitute facilities. To simplify the future projection process, the recreation planner should isolate which variables are likely to undergo significant change and adjust base year usage and visitor-day value estimates as a function of anticipated changes in those variables.

Estimating Facility Life

The recreational planner will need to choose an estimated facility life over which to evaluate the recreational benefits assigned to the usage of a facility. The facility life chosen to evaluate recreational benefits might be tied to the time period over which the project costs are to be paid off, if local bond financing is to be used, or to a reasonable planning horizon selected. Depending on the type of facility and form of financing, an economic life of 20-30 years might be chosen. Of course, in no case should the planning horizon choosen be greater than the estimated physical life of the facility.

Uncertainty in Estimating Future Usage and Visitor-Day Values

A major constraint in estimating the future benefits from development of recreational facilities in connection with water resource management projects is the presence of uncertainty surrounding the future stream of costs and benefits. Uncertainty arises as a result of such factors as unanticipated price variation, rate of growth in the region's economy, and changes in consumers' tastes. In this paper, we suggest that estimates of the distribution of demand over the geographic area served by a proposed facility be made for severl scenarios (an example in the appendix is used to illustrate this procedure). The objective is to incorporate some degree of sensitivity analysis into the benefit calculation based on varying assumptions about the cost of gasoline, recreational activity costs and income changes. Beyond this process,

however, it is recommended to provide a further degree of sensitivity analysis in computing the present value of future benefits generated by using a range of discount rates.

Choosing the Discount Rate

The calculation of present value enables comparison of resource use in the future with resource use in the present. Under the discounting procedure, both the magnitude of future benefits and the timing of their occurence is relevant in magnitude of future benefits and the timing of their occurence is relevant in evaluating the benefit stream. The most appropriate discount rate is the opportunity cost of capital in terms of the potential rate of return to the public for making an investment. There are, however, practical problems for the analyst in determining the appropriate rate of return, as opportunity costs are likely to vary throughout the economy based on such factors as tax policies, the presence of externalities, and the existence of risk. In theory, the discount rate should just reflect the choice made by society as whole between present and future returns. There are those who argue that the discount rate should not be below the prevailing market interest rate as a rule of thumb. Others argue that because capital put to public use often has a higher social return that capital put to private use, the discount rate chosen should be lower for public than for private project. A note of caution should be interjected, however -- use of a lower discount rate can make projections of a favorable cost-benefit ratio self-fulfilling, and should only be used if the project will generate true positive externalities or social returns.

Calculating the Present Value of Future Benefits

Recall that to decide whether construction of a recreational facility is justified, the present value of total benefits generated over the life of the facility must be compared to total costs discounted over the life of the facility. A full measure of recreational benefits includes both those proxied by user costs incurred and those represented by the consumer surplus which recreationists enjoy, and benefits proxied by cost incurred equal user costs incurred by definition. Hence, the condition that total benefits should equal or exceed total costs implies that consumer surplus should equal or exceed project costs if a particular recreational project should be built.

The formula for calculating the present value of a future stream of benefits is as follows:

$$\text{Present Value of Benefits} = \sum_{n} \frac{\text{Value of Benefits}}{(1 + r)^n} \qquad (18)$$

where: Value of Benefits = Consumer surplus in period n
n = the number of periods in the estimated life of the facility
r = the discount rate

For example, if the annual consumer surplus enjoyed by recreationists in the surrounding time zones is estimated to remain constant at $10,000, the estimated facility life is 10 years, and a discount rate of 10% is chosen, the present value of benefits is $61,484. If project construction, maintenance an operating costs discounted to the present are less than or equal to this amount, then the project is justified from a cost-benefit standpoint and it should be built. ABAG has developed a computer program for discounting cost estimates. This program is available to any counties or agencies participating in the Environmental Management Program.

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* The Water Resources Council prescribes using a discount rate of 6-3/8%. Long-term federal bond interest rates can be used for sensitivity analysis purposes.

VI. CONCLUSION

This paper has presented a methodology that can be used to evaluate recreational benefits associated with water quality programs. Our focus has been on designing a process that will assist public decision-makers in the task of allocating scarce public resources among alternative uses through the use of cost-benefit analysis. Implicit in this undertaking is the argument that if it is possible to increase the value of benefits of the economy's output for any given amount of resource input, than an improvement in economic efficiency is attainable in the economy. If the benefits generated by a proposed expansion of recreational opportunities exceed or equal the costs to users and to the public through project construction, then the provision of additional recreational facilities represents a net gain in society's welfare. We have defined the relevant benefits as those proxied by what recreationists actually exchanged in order to participate in a recreational activity (user costs), and what they would be willing to pay over and above costs actually incurred (consumer surplus). The methodology considers the influence of changes in income on the demand for recreational activity, and can allow for adjustments in gasoline and other travel costs (including the opportunity cost of time spent in travel), activity costs, and population size. For the purposes of simplicity, a strong assumption was made that there is a relatively homogeneous population with respect to tastes and income surrounding the proposed recreational facility. However, this assumption could be relaxed with further refinements.

Given these considerations, this paper represents an innovative approach at designing a methodology to assess benefits from water resource management projects that can result in expansion of recreational opportunities.

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APPENDIX A

OUTLINE OF PROCEDURE TO FOLLOW IN ESTIMATING
FACILITY USAGE AND VALUE OF RECREATIONAL BENEFITS

A. Annual Facility Usage

1. Define the area to be served by the proposed facility according to travel time zones, using ABAG's travel matrix.

2. Estimate the population residing in each of the travel time zones, using ABAG's population data by 440 zones.

3. Estimate the annual potential demand for the recreational activity from the surrounding population that would be served by the proposed facility according to the formula:

   Annual Potential Demand = (Per Capita Annual Demand x Population$_i$),

   where i = each travel time zone.

4. Calculate the unmet recreation demand of the surrounding population according to formula (a) or formula (b):

   (A) Unmet Demand = Annual Potential Demand - Demand met by existing supply of facilities in service area, or

   (b) Unmet Demand = Annual Potential Demand x (1 - ($\frac{\text{Existing Facilities}}{\text{Needed Facilities}}$))

   Make adjustments as necessary to take account of peak usage patterns.

5. Calculate the visitor-day potential of the proposed facility, which is the unmet demand that can be satisfied by the proposed facility, according to the formula:

   Visitor-Day Potential = Min(Capacity of Facility, Unmet Demand)

   Make adjustments as necessary to take account of peak usage patterns.

6. Distribute the visitor-day potential that can be satisfied by the proposed facility over the population in the surrounding time zones, following steps (a) and (b):

(a) Calculate the conditional distribution of demand as a function of price according to the formula:

$$D(P) = e^{-k(p_i)^a}$$

(B) Normalize D(P) coefficients by the following process

$$N(P)_i = D(P_i) / \sum_{i=1}^{n} D(P)$$

(C) Calculate Demand by zone

$$pZp = N(P) \times Zp$$

$$Pc_i = pZp / \sum_{i=1}^{n} pZp$$

$$V_i = V \times Pc_i$$

where $N(P)_i$ = normalized demand coefficients for zone i.

Zp = zone population in Base Year or Forecast year.

Pc_i = conditional probability of demand in zone i.

V = visitor-days estimate supplied by the new proposed facility

pZp = zone potential demand.

This completes the procedure for estimating annual facility usage for the surrounding population in the service area of the proposed facility.

B. Value of Recreational Benefits

1. Calculate the value of costs incurred in recreating at the proposed facility for an individual from each travel time zone according to the formula:

$$CI_i = (Tc_i + Oc_i + Ac) \text{ (visitor-days)}$$

2. Sum the value of costs incurred over all time zones:

$$CI = \sum_i CI_i$$

3. Calculate consumer surplus associated with each time zone:

$$CS_o = \int_{P_1}^{Pn} g(p)dp.$$

4. Sum the value of consumer surplus over all time zones:

$$CS = \sum_i CS$$

5. Sum value of costs incurred and consumer surplus to obtain measure of total benefits in year n:

$$TB_n = CI_n + CS_n$$

6. Estimates of recreational benefits should be carried into the future over the estimated life of the facility and discounted to determine the present value of total recreational benefits from the new facility according to the formula:

$$\sum_n \left(\text{value of benefits}_n / (1 + r)^n\right)$$

where: n = the number of periods in the estimated life of the facility.

r = the discount rate

Value of Benefits = total benefits in year in or consumers surplus in year in (depending on whether comparison is to be made with total costs or project costs, respectively).

This completes the procedure for estimating the total recreational benefits that will be generated by a proposed project.

APPENDIX B

EXAMPLE OF PROCESS USED TO SOLVE FOR VALUE OF RECREATIONAL BENEFITS FOR PICNICKING FACILITIES

A. Annual Facility Usage

1. Assume per capita-visitor days are 15.00 visitor/days per year.

2. Assume service area consists of 1000 people.

3. 1 X 2 = Total potential demand 15 x 1000 = 15,000 visitor-days/year

   Peak Daily Demand = 1500 visitor-days/yr x .01 .485 = 7.275

4. Calculate unmet demand. In this case, we have estimated the total potential demand in visitor-days/year as being 1500. Now, let us assume that within the service area there exists in the supply of picnicking facilities enough to meet the demand of 1000 visitor-days/year. Hence, 15,000-10,000 = the potential unmet demand. If, however, the potential demand were 10,000 visitor-days/year, and the existing supply were 15,000 visitor-days, an excess of supply over demand would exist. If this occurs then according to this analysis, new recreational facilities would not be justified in terms of demand.

5. In this case, however, we have calculated the visitor-days/year as exceeding supply by 5000 visitor-days/year. Now, the recreational planner has calculated that the water resource project could provide 2500 visitor-days/year of supply of new recreational facilities.

6. At this point, the planner would like to determine the demand population in order to calculate the potential value for the facility. The required information are:

   1) Price of gasoline in base year
   2) User activity cost
   3) Mean wage rate in study area
   4) Persons per vehicle
   5) Average miles per gallon for autos
   6) Range of time and distance
   7) Deflator of mean wage rate
   8) Total population by zone

Given this data, the planner should use Table A-2 to calculate the demand distribution. As an illustration, cost calculations are performed for specific time zones.

(a) With Equation (10) calculate Opportunity costs for the 15 min - 4 mile zone. The opportunity cost is \$2.13 associated with travel. This is calculated by: (\$8.50/60) x N x 15 min, N = 1. Note that the planner may consider opportunity cost to the significant or, insignificant. Given this, N is a variable which inflates or deflates the opportunity cost.

(b) Using Equation (8) calculate Transportation costs for the 15 min - 4 mile zone:

((1.25/18 miles/gallon) x 8)/2.5* persons per vehicle = .22 or 22 cents/one way trip

*2.5 assumes everyone contributes equally to cost

(c) Calculate demand coefficients:

Using Equation (5) as developed in Section 3, we calculate

$k\ ((1/\ln \text{total visitor-days})\ (\ln P_{in}/P_{im}))$

$k = (1/\ln 2500)\ (\ln (4.35/22.88))$

$k = -.21277$

zone pop = 1000

$P = \$2.13 + .22 + 2.00 = \$4.35$

$P = \$17.00 + 3.88 + 2.00 = \$22.88$

*For example, at \$4.35 cost, $D(p) = e^{-.21271\ (4.35)}$

$D(p) = .3963$

*Perform calculation for all zones.

Calculate Demand:

.3963 x 1000 (zone population)
396 potential demand
.1693 = 396/sum of all potential demand (2338)
423 = .1693 x 2500
423 = visitor - days generated in zone 1.

B. Value of Recreational Benefits

1. Calculate Consumer Surplus.

For zone 1 in 1980.

$$CS_0 = \int_{4.35}^{22.88} (2500 \times 4.35) / .2121)(e^{-.2121\ (4.35)} - e^{-.2121\ (22.88)})$$

$$CS_0 = \int_{4.35}^{22.88} 51258\ (e^{-0.9226} - e^{-4.85})$$

$$CS_0 = \$19979$$

Now for zone 1 the population is equal to 5000 individuals. The normalized demand coefficient is, 4122. The steps used to adjust the CS_0 value are:

Step 1 - Multiply normalized demand coefficient by total visitor-day demand

0.4122 x 2800 = 1031 visitor-days

Step 2 - Divided Visitor-days into CSo

$19,979/1031 = $19.37/Visitor-day

Step 3 - Multiply the demand coefficient for each zone by the population in each zone. For example for zone 1, 0.4122 x 5000 = 2061 Equal weighted zone population.

Step 4 - Sum of the weighted zone population calculated in Step 3 and divide the sum into the weighted zone to obtain the probability of demand for the zone. In this case of zone 1, this factor is 0.4569.

Step 5 - Multiply the probability 0.4569 x 2500. This provides an estimte of the demand for zone 1 weighted for population.

Step 6 - Multiply the weighted demand by the per visitor-day value. For example, zone 1, 1142 x $19.37 = $22,125 on the (CS) value associated with the actual potential demand from zone 1.

TABLE B-3

Hypothetical Visitor-Day Demand Distribution and Annual Benefits for Picnicking Examples

Travel Zone Minutes	1980			1985		
	Visitor-Days (V)	Value Capture By Costs	Consumer Surplus (C)	Visitor-Days (G)	Value Captured by Costs (C)	Consumer Surplus (C)
15	1142	$4968	$22132	1355	6531	18444
30	695	4650	13316	693	5288	10055
45	329	3010	6165	268	2859	3855
60	193	2250	3484	126	1743	1835
75	81	1162	1344	41	710	594
90	45	769	640	17	356	0
105	8	159	75	0	0	0
120	6	137	0	0	0	0
		$17105	$47156		$17487	$34410

(a) Annual Benefits Generated for 2500 Visitor-Days

(b) Numbers may not sum to 2500 because of rounding

(c) Constant 1980 Dollars

Source: ABAG Calculations.

Now, after you have calculated the (CS) value for each zone the analyst should perform the following:

Step 1 - Sum all consumer surplus values. = Potential supply x normalized coefficient for zone i

Step 2 - Calculate benefits captured by costs of travel and participating in the recreational activity

Annual Benefits captured by costs = Total Cost x Visitor - Days by zone where Total Cost = $(Tc_i + Ac + Oc_i)$

Step 3 - Sum consumer surplus plus annual benefits captured by costs. This provides an estimate of total benefits associated with the construction of the recreational site facility.

In this example, user costs rise faster than real incomes. As a consequence, usage of the facility becomes more concentrated among the residents of close in zones. In addition, the value of consumer surplus falls. The latter relationship is indicated in Figure 6, which shows that the 1985 demand function shifts inward and steepens in slope. The increased concentration of users from close-in zones (who face lower user costs relative to further-out zones and hence enjoy greater consumer surplus) is not great enough to offset this effect.

Table B-4′

FACTORS USED TO DISTRIBUTE DEMAND AND VALUE OF RECREATIONAL SERVICES BY TIME COHORTS

	1980	1985
Activity Name	Picnicking	Picnicking
Gasoline Price (Base Year Prices)	$1.25 a gallon	$2.50 a gallon
User Activity Cost (Base Year Prices)	$2.00	$2.00
Real Income Growth (%)	---	12%
Mean Wage Rate for Study Area (Constant Base Year Dollars)	$8.50	$9.50
Deflator Factor for Wage	1.0	1.0

Year 1980

Distance	4 miles	8 miles	14 miles	21 miles	31 miles	42 miles	55 miles	70 miles
Time	15 min.	30 min.	45 min.	60 min.	75 min.	90 min.	105 min.	120 min.
Opportunity Cost	$2.13	$4.25	$6.38	$8.50	$10.63	$12.75	$14.88	$17.00
Transportation Cost	$0.22	$0.44	$0.77	$1.16	$1.72	$2.33	$3.05	$3.88
Consumer Surplus	$22132	$13316	$6165	$3484	$1344	$640	$75	$0
Normalized demand Coefficient	.4122	.2505	.1484	.0869	.0490	.0274	.0149	.0104
Population	5000	5000	4000	4000	3000	3000	1000	1000
Conditional Probability	.4569	.2778	.1317	.0772	.0325	.01818	.0033	.0022
Demand	1142	695	329	193	81	45	8	6

Year 1985

Opportunity Cost	2.38	4.75	7.12	9.50	11.88	14.25	16.63	19.00
Transportation Cost	0.44	0.88	1.55	2.33	3.44	4.67	6.11	7.77
Consumer Surplus	18444	10055	3855	1835	594	0	---	---
Normalized Demand Coefficient	.5138	.2626	.1270	.0596	.0259	.0109	0	---
Population	5000	5000	4000	4000	3000	3000	1000	1000
Conditional Probability	.5420	.2770	.1072	.0502	.0165	.0069	---	---
Demand	1355	693	268	126	41	17	---	---

FIGURE 6. Impact of change in price of gasoline between 1980 and 1985 on the demand coefficient

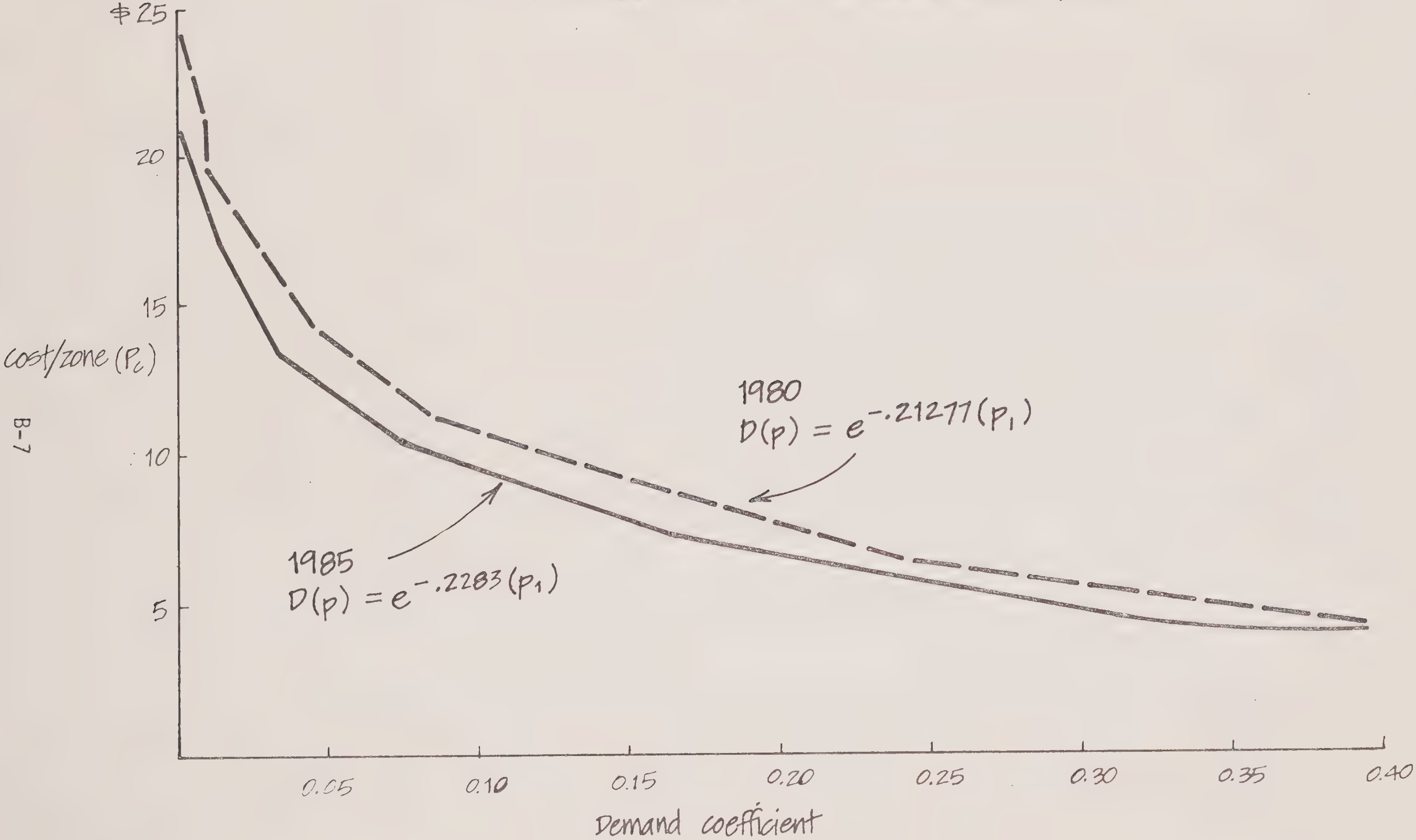

Table C-1

An Example of Travel Time Data
1975 Peak-Hour Highway Times in Minutes
from Zone 130 (University of California)

ZONES	01	02	03	04	05	06	07	08	09	10
1-10	51.3	55.7	62.4	49.1	51.6	48.0	57.6	49.6	46.9	55.8
11-20	48.6	48.9	44.4	42.1	44.9	48.1	55.2	50.4	47.8	54.0
21-30	51.4	62.3	85.8	82.3	58.3	54.0	51.2	55.2	55.2	55.6
31-40	66.9	66.5	77.1	75.8	88.8	84.4	85.8	83.2	85.5	82.1
41-50	85.8	84.0	86.9	105.3	98.2	115.2	114.2	118.1	118.0	98.3
51-60	85.9	83.5	79.3	76.2	62.2	53.9	45.6	47.3	47.2	49.8
61-70	53.3	55.8	48.9	59.4	61.1	69.9	78.3	100.5	84.0	83.8
71-80	75.5	72.8	56.7	62.0	61.7	68.2	65.1	67.7	67.0	75.1
81-90	93.2	83.5	56.0	51.2	42.0	38.5	42.1	39.0	36.5	29.5
91-100	24.6	25.9	32.2	35.4	30.3	37.2	41.8	35.7	38.7	43.4
101-110	47.0	53.8	53.2	48.0	44.4	43.5	36.1	51.3	51.8	36.6
111-120	38.7	35.6	31.6	35.1	27.2	27.0	25.7	31.0	28.3	23.8
121-130	19.0	21.5	12.1	14.9	16.2	18.1	15.7	14.2	13.8	13.1
131-140	13.7	11.5	15.3	15.4	23.5	19.9	16.0	20.1	22.4	26.8
141-150	25.8	30.6	28.0	27.0	23.4	30.4	27.9	25.5	18.5	24.2
151-160	22.5	24.3	30.1	31.0	29.6	30.4	24.2	25.3	29.0	30.0
161-170	30.4	33.5	32.9	32.8	37.1	34.7	38.0	41.0	41.9	42.3
171-180	36.5	32.9	33.4	29.8	36.1	38.4	42.0	43.3	35.0	34.4
181-190	38.2	42.2	45.8	40.1	44.0	47.8	51.4	48.3	47.0	50.3
191-200	50.5	52.9	57.4	55.3	57.8	59.2	60.0	61.9	66.7	66.1
201-210	61.0	61.3	65.8	64.8	49.5	51.6	56.3	56.6	53.3	54.9
211-220	57.3	62.9	61.3	64.6	63.6	65.7	101.2	122.2	115.1	108.1
221-230	102.5	121.0	101.2	97.4	91.6	97.0	86.1	84.0	87.6	88.7
231-240	85.8	90.8	95.1	92.2	89.4	92.9	93.1	92.5	96.4	99.4
241-250	94.5	94.1	92.9	86.9	90.2	86.3	90.4	89.7	88.4	84.4
251-260	84.2	85.2	87.5	84.1	86.2	80.9	81.8	79.1	76.7	77.3

Table C-1
(con't)

Zones	01	02	03	04	05	06	07	08	09	10
261-270	78.0	79.1	80.1	80.3	82.8	82.9	81.5	84.1	79.1	80.1
271-280	77.5	79.9	80.5	80.9	83.6	85.9	81.8	82.2	88.8	83.8
281-290	87.7	86.4	91.1	92.3	92.5	89.3	82.8	84.6	87.3	82.0
291-300	77.2	76.2	77.4	75.2	71.2	73.5	70.9	85.2	83.1	79.6
301-310	77.8	79.6	82.0	88.6	88.2	75.8	73.0	76.0	75.8	85.7
311-320	62.6	60.1	76.4	77.0	85.4	85.0	82.2	78.3	80.2	77.9
321-330	74.2	74.7	73.1	72.8	68.0	69.7	68.6	102.2	84.3	78.9
331-340	70.6	70.2	69.2	72.8	66.7	67.1	67.3	66.2	66.3	63.4
341-350	63.1	61.6	65.2	65.2	64.0	64.7	57.0	62.1	57.8	58.2
351-360	59.6	59.9	55.8	62.2	62.7	58.7	54.6	51.8	58.3	55.7
361-370	55.8	54.5	52.5	54.0	51.9	52.2	45.2	43.8	42.4	41.8
371-380	42.3	43.0	45.7	48.5	48.1	47.6	50.9	56.4	42.2	40.0
381-390	37.8	34.1	37.0	37.9	41.0	40.2	41.1	42.5	44.6	43.6
391-400	47.3	47.6	50.5	52.6	40.6	42.3	43.3	49.2	52.0	53.1
401-410	50.8	57.7	55.0	46.3	52.7	53.9	50.2	50.3	52.3	47.0
411-420	49.1	47.1	43.8	43.3	45.0	42.9	44.1	43.0	40.9	41.1
421-430	39.6	39.9	40.0	40.8	36.5	39.1	36.0	36.2	36.8	39.0
431-440	39.7	42.0	41.7	40.3	42.7	45.2	44.8	44.3	47.9	47.1


SEE
INSET
440 ZONES
BASED ON 1970 CENSUS TRACTS
1:1,000,000
1 in = approx. 16 miles

TABLE C-2

Example of Population Projections for 440 Zones
San Francisco Bay Area*

COUNTY	ZONE	1980	1985	1990	1995	2000
3	1	2849.	3482.	4120.	4470.	4619.
3	2	7638.	8053.	8440.	8912.	9370.
3	3	9603.	10361.	10753.	10881.	10721.
3	4	7561.	9806.	11383.	12438.	12896.
3	5	13331.	13521.	13765.	14091.	14213.
3	6	8993.	9806.	10698.	11232.	12593.
3	7	9205.	9826.	9774.	9984.	9884.
3	8	5996.	6285.	7386.	7679.	8191.
3	9	10018.	9947.	10068.	10222.	10393.
3	10	11775.	11922.	12223.	12452.	12778.
3	11	4010.	3864.	4075.	4224.	4345.
3	12	7231.	7078.	7004.	7031.	7046.
3	13	4880.	4804.	4755.	4739.	4732.
3	14	8547.	8670.	8970.	9055.	9081.
3	15	10487.	11334.	12685.	13129.	13377.
3	16	7521.	8492.	10163.	11398.	12748.
3	17	4660.	4445.	4559.	4731.	4939.
3	18	14477.	14548.	15606.	17299.	18035.
3	19	5443.	5848.	6391.	6545.	6640.
3	20	7257.	7185.	7258.	7326.	7408.
3	21	4672.	4516.	4433.	4536.	4803.
3	22	3059.	3491.	3666.	3726.	3831.
3	23	5752.	5655.	5529.	5539.	5649.
3	24	6688.	7068.	7367.	7329.	7540.
3	25	13145.	13224.	14815.	16820.	17987.
3	26	10166.	10079.	10032.	10034.	10735.
3	27	6460.	6666.	6674.	6945.	7163.
3	28	1475.	1428.	1395.	2562.	3762.
3	29	3374.	6129.	6860.	11505.	16106.
3	30	9619.	11871.	13974.	15789.	16643.
MARIN TOTAL		225891.	239408.	254819.	272622.	288226.
9	31	16373.	18434.	21074.	25701.	28111.
9	32	18075.	19768.	20006.	24218.	31187.
9	33	36426.	48105.	49556.	55292.	62165.
9	34	29811.	31091.	35307.	40075.	47735.
9	35	21425.	24889.	28227.	30417.	32180.
9	36	22057.	22451.	23108.	23717.	24215.
9	37	9472.	9164.	8961.	8870.	8785.
9	38	2386.	2315.	2271.	2248.	2227.
9	39	9759.	9559.	9463.	9429.	9379.
9	40	3775.	3634.	3545.	3491.	3440.
9	41	14443.	15494.	16647.	17488.	18135.
9	42	33614.	40332.	41230.	42233.	43032.
9	43	20308.	21396.	23889.	26549.	28709.
9	44	14326.	15755.	17781.	19173.	20078.
9	45	18180.	21469.	25049.	28231.	37181.
9	46	7600.	7799.	8581.	9235.	10278.
SONOMA TOTAL		278029.	311654.	334696.	366367.	401836.

* These projections are shown for illustration only. They do not represent adopted ABAG projections.

TABLE C-2 *(Cont.)*

COUNTY	ZONE	1980	1985	1990	1995	2000
4	47	4223.	4138.	4118.	4252.	4620.
4	48	5551.	5573.	5600.	5673.	5778.
4	49	453.	436.	423.	417.	410.
4	50	7051.	8318.	9241.	9252.	9349.
4	51	7098.	7006.	6981.	7094.	7258.
4	52	8056.	8569.	9181.	10086.	10911.
4	53	12488.	12515.	12219.	12157.	12147.
4	54	41808.	43779.	42839.	42673.	42669.
4	55	11529.	14984.	16004.	16932.	17456.
NAPA TOTAL		98257.	105319.	106607.	108535.	110598.
8	56	15909.	21684.	24673.	25163.	25750.
8	57	12508.	13024.	12859.	16333.	20448.
8	58	13707.	13672.	13451.	13465.	13474.
8	59	8240.	7943.	7797.	7873.	7951.
8	60	14598.	14274.	14040.	13900.	13753.
8	61	4636.	4673.	4731.	4886.	5107.
8	62	5642.	6182.	6099.	5990.	5883.
8	63	16692.	16923.	20510.	24581.	35344.
8	64	4386.	10653.	12787.	16093.	20238.
8	65	15612.	22969.	23808.	24705.	24990.
8	66	42956.	43900.	43499.	44348.	45448.
8	67	10029.	9825.	9711.	9829.	10067.
8	68	3742.	3679.	3938.	4016.	4171.
8	69	2483.	2418.	2371.	2348.	2979.
8	70	6974.	9041.	11021.	11801.	13174.
8	71	8389.	17524.	21602.	30046.	37947.
8	72	36022.	42130.	41318.	41349.	41700.
SOLANO TOTAL		222524.	260512.	274216.	296725.	328426.
2	73	9838.	12323.	12122.	12035.	12191.
2	74	9304.	9177.	8902.	8944.	8945.
2	75	17729.	20044.	21522.	23967.	26152.
2	76	5044.	4822.	4684.	4744.	4837.
2	77	20115.	21774.	21806.	22735.	23746.
2	78	7758.	10527.	10692.	11269.	11889.
2	79	3716.	7267.	7638.	8402.	9208.
2	80	4724.	4501.	4752.	5506.	7045.
2	81	4835.	8967.	8895.	9121.	9673.
2	82	6625.	8420.	8637.	9648.	11016.
2	83	15155.	20542.	25900.	32502.	36588.
2	84	29008.	38663.	42024.	43399.	45469.
2	85	10662.	10973.	12724.	12743.	12577.
2	86	2671.	2574.	2532.	2508.	2488.
2	87	12478.	18494.	22373.	23637.	24734.
2	88	7421.	8891.	8993.	8992.	8841.

TABLE C-2 *(Cont.)*

COUNTY	ZONE	1980	1985	1990	1995	2000
2	89	15167.	17518.	20878.	25085.	27255.
2	90	4987.	4983.	5074.	5240.	5332.
2	91	6860.	6647.	8131.	8945.	8959.
2	92	7118.	8079.	8290.	8206.	8057.
2	93	10821.	12007.	12858.	13748.	14540.
2	94	17089.	19770.	21877.	23907.	26039.
2	95	7943.	7710.	11501.	12516.	12413.
2	96	13632.	13670.	13585.	14124.	14694.
2	97	8809.	8759.	8841.	8935.	9127.
2	98	6151.	5976.	6479.	6355.	6235.
2	99	21319.	21409.	21166.	21644.	22144.
2	100	17695.	18395.	20519.	32591.	34008.
2	101	12773.	14697.	15026.	15121.	15598.
2	102	16878.	18026.	19359.	19528.	20128.
2	103	34427.	33486.	35047.	35109.	35872.
2	104	27173.	26220.	26192.	25789.	25590.
2	105	9774.	9764.	10738.	10743.	10935.
2	106	23420.	28576.	32222.	36285.	37975.
2	107	1889.	1815.	1762.	1732.	1702.
2	108	7884.	10031.	11728.	12012.	12671.
2	109	14647.	15176.	15935.	16109.	17494.
2	110	25843.	30851.	33904.	36384.	37663.
2	111	9578.	9530.	9784.	10127.	10407.
2	112	4095.	3870.	4843.	5982.	7382.
2	113	27893.	29085.	29773.	30278.	31086.
2	114	20451.	23487.	25586.	27473.	28651.
2	115	13082.	12578.	12463.	12684.	13236.
2	116	12256.	11766.	11691.	11778.	12139.
2	117	10598.	10603.	15358.	17161.	17548.
2	118	12832.	12232.	12036.	12110.	12478.
2	119	10277.	10171.	10080.	10261.	10684.
2	120	4705.	4671.	4638.	4569.	4592.
2	121	10387.	10034.	9981.	10061.	10184.
2	122	13458.	13362.	13279.	13582.	14208.
CONTRACOSTA TOTAL		628994.	692915.	744818.	796327.	832422.
1	123	8120.	8884.	9004.	9423.	9876.
1	124	7836.	7683.	7660.	7956.	8276.
1	125	13621.	13390.	13434.	14054.	14642.
1	126	6872.	8947.	8796.	8907.	8770.
1	127	6881.	6744.	6716.	6789.	6897.
1	128	12822.	12589.	12619.	13077.	13594.
1	129	9711.	9701.	10023.	10531.	11078.
1	130	7514.	7423.	7391.	7484.	7632.
1	131	2229.	2585.	2997.	2995.	2953.
1	132	11644.	11600.	11637.	11984.	12404.
1	133	20059.	20120.	20511.	21347.	22303.
1	134	16919.	16628.	16659.	17339.	18100.

TABLE C-2 *(Cont.)*

COUNTY	ZONE	1980	1985	1990	1995	2000
1	135	7011.	6936.	6824.	6748.	6674.
1	136	15444.	15131.	14936.	15328.	15724.
1	137	16325.	16029.	15897.	16316.	16754.
1	138	11444.	11227.	11196.	11493.	11875.
1	139	9962.	9785.	9709.	9780.	9912.
1	140	8979.	8756.	8574.	8736.	8903.
1	141	4182.	4251.	4342.	4577.	4870.
1	142	1911.	1879.	1855.	1832.	1811.
1	143	3257.	3217.	3227.	3200.	3180.
1	144	7008.	6933.	6974.	6925.	6890.
1	145	25080.	24704.	24670.	25344.	26081.
1	146	21395.	21000.	20839.	21575.	22312.
1	147	15526.	15229.	15093.	15688.	16355.
1	148	11328.	10920.	10770.	10654.	10544.
1	149	6517.	6455.	6405.	6698.	7020.
1	150	11104.	11419.	12039.	12999.	13988.
1	151	6118.	6398.	6843.	7379.	7922.
1	152	6810.	11307.	17698.	19424.	20738.
1	153	7075.	7113.	11617.	12184.	12419.
1	154	15258.	15465.	15313.	15740.	16249.
1	155	18346.	18134.	17928.	18439.	19049.
1	156	15527.	15321.	15107.	15543.	16059.
1	157	13122.	13030.	12963.	13439.	13992.
1	158	16451.	16300.	16184.	16784.	17471.
1	159	20787.	20527.	20266.	20808.	21460.
1	160	16699.	16486.	16244.	16700.	17236.
1	161	5154.	5949.	6022.	5985.	5999.
1	162	12760.	12640.	12462.	12627.	12885.
1	163	8984.	8817.	8636.	8636.	8654.
1	164	13922.	15562.	15621.	15973.	16362.
1	165	10854.	10768.	10892.	11361.	11918.
1	166	16333.	16237.	16638.	17603.	18634.
1	167	6212.	6114.	6415.	6723.	7034.
1	168	6332.	11130.	12904.	13662.	14351.
1	169	0.	0.	0.	0.	0.
1	170	7386.	7104.	6900.	8034.	9366.
1	171	3500.	3423.	3381.	3343.	3343.
1	172	8706.	8554.	8447.	8607.	8812.
1	173	14544.	14314.	14165.	14495.	14893.
1	174	19511.	19135.	19129.	19696.	20379.
1	175	19460.	19105.	19110.	19398.	19665.
1	176	12707.	12904.	14359.	15637.	16739.
1	177	26718.	26510.	25900.	28043.	29450.
1	178	22403.	22453.	22959.	23356.	23244.
1	179	14904.	14979.	15773.	17216.	18277.
1	180	4483.	4553.	4525.	4538.	4572.
1	181	9762.	9640.	9494.	9541.	9608.
1	182	9464.	9320.	9262.	9504.	9772.
1	183	10088.	9909.	9903.	10257.	10658.
1	184	12152.	13375.	13211.	13059.	12903.

TABLE C-2 *(Cont.)*

COUNTY	ZONE	1980	1985	1990	1995	2000
1	185	10429.	10712.	10941.	11239.	11633.
1	186	5305.	7959.	8311.	8264.	8117.
1	187	11136.	15043.	20109.	28200.	28846.
1	188	18432.	21045.	22994.	24162.	25286.
1	189	24403.	24308.	25269.	25925.	26683.
1	190	19325.	24299.	25321.	25998.	26718.
1	191	17102.	16900.	17038.	17378.	17810.
1	192	13958.	15946.	18188.	18813.	19325.
1	193	8276.	8123.	8590.	8896.	9210.
1	194	33053.	36645.	38900.	40092.	40004.
1	195	23362.	25107.	30700.	31894.	32747.
1	196	24077.	24228.	25066.	25469.	25972.
1	197	4300.	5061.	5104.	5216.	5348.
1	198	11500.	14407.	14724.	15326.	15967.
1	199	17778.	19381.	19529.	20143.	20855.
1	200	16169.	21874.	22447.	23310.	24247.
1	201	18015.	19586.	19685.	20263.	20795.
1	202	15120.	17763.	17932.	18454.	18902.
1	203	25884.	26128.	26671.	26926.	27258.
1	204	9348.	13239.	18741.	19334.	19686.
1	205	9340.	10102.	10811.	10913.	10994.
1	206	4905.	6264.	7993.	8461.	8852.
1	207	1654.	1696.	1735.	1804.	1898.
1	208	13297.	15457.	15548.	15798.	16105.
1	209	10266.	12057.	12818.	13228.	13625.
1	210	1874.	3654.	3728.	3682.	3621.
1	211	9285.	10056.	10079.	9902.	10870.
1	212	17508.	17512.	18375.	19847.	20899.
1	213	14866.	17754.	20417.	22311.	24780.
1	214	11529.	12239.	14295.	17063.	18372.
1	215	3794.	4323.	4791.	7261.	8366.
1	216	2368.	2238.	2144.	2092.	2112.
ALAMEDA TOTAL		1140892.	1203847.	1256061.	1311177.	1355433.
7	217	607.	570.	543.	528.	513.
7	218	21127.	24330.	29308.	30463.	31970.
7	219	5479.	7624.	9903.	10911.	11339.
7	220	13754.	16647.	21374.	24491.	28011.
7	221	1814.	1746.	3163.	3763.	3957.
7	222	1141.	1095.	1061.	1042.	1024.
7	223	3479.	3366.	3284.	3242.	3201.
7	224	30545.	32400.	39568.	42426.	45673.
7	225	48926.	58521.	59947.	61657.	62901.
7	226	53581.	56987.	61931.	65137.	66817.
7	227	25225.	34754.	51897.	63265.	72319.
7	228	9851.	11832.	14647.	15340.	15569.
7	229	26787.	27353.	28609.	30018.	31449.
7	230	6302.	7298.	7459.	7517.	7528.

TABLE C-2 *(Cont.)*

COUNTY	ZONE	1980	1985	1990	1995	2000
7	231	17541.	20165.	21681.	24132.	26124.
7	232	19334.	19032.	19091.	19463.	19736.
7	233	21166.	22016.	24380.	25188.	25644.
7	234	20792.	20473.	20708.	21347.	21741.
7	235	13674.	13663.	13747.	13936.	14073.
7	236	30033.	31051.	31764.	32798.	33556.
7	237	5078.	4985.	5007.	5139.	5243.
7	238	14718.	14907.	15793.	16702.	17485.
7	239	8134.	7903.	8741.	9719.	10690.
7	240	12926.	13141.	13448.	15533.	17911.
7	241	12502.	13899.	15503.	17014.	18107.
7	242	13551.	15818.	16154.	16416.	16497.
7	243	16860.	17055.	17265.	17534.	17714.
7	244	20206.	19906.	21958.	22455.	22681.
7	245	17844.	18257.	18578.	19043.	19305.
7	246	17632.	17579.	17611.	17648.	17666.
7	247	9887.	9528.	9398.	9238.	9080.
7	248	24983.	24385.	24461.	24784.	24990.
7	249	23316.	22936.	23222.	24004.	24249.
7	250	25281.	26643.	28977.	30695.	31556.
7	251	8749.	8885.	8907.	9024.	9061.
7	252	13702.	16828.	18764.	21005.	22362.
7	253	5024.	5000.	5025.	5141.	5224.
7	254	1642.	1834.	1876.	1847.	1818.
7	255	13186.	12886.	13006.	13325.	13573.
7	256	20164.	20101.	20037.	20199.	20415.
7	257	7276.	7570.	7541.	7657.	7696.
7	258	12371.	12583.	12640.	12634.	12621.
7	259	9307.	9230.	9394.	10001.	10467.
7	260	3889.	3954.	4136.	4344.	4535.
7	261	2595.	2518.	2499.	2496.	2493.
7	262	5152.	5146.	5182.	5304.	5379.
7	263	3831.	3740.	3740.	3679.	3637.
7	264	10924.	10905.	11178.	11435.	11597.
7	265	3674.	3644.	3661.	3673.	3706.
7	266	10557.	10593.	10408.	10499.	10488.
7	267	25264.	26243.	26227.	26973.	27333.
7	268	7737.	8225.	9276.	12291.	13171.
7	269	18239.	20301.	20676.	21164.	21434.
7	270	19068.	21466.	21657.	21888.	21954.
7	271	1829.	1785.	1789.	1760.	1732.
7	272	2083.	2068.	2136.	2213.	2285.
7	273	3962.	3873.	3854.	3927.	3948.
7	274	7699.	7582.	7448.	7408.	7392.
7	275	9694.	9489.	9453.	9692.	9790.
7	276	13894.	13617.	13612.	13956.	14188.
7	277	8675.	8581.	8992.	9865.	10294.
7	278	28992.	28365.	29508.	32119.	33540.
7	279	40088.	43211.	45782.	48158.	50234.
7	280	21859.	23896.	25660.	27035.	28091.

TABLE C-2 *(Cont.)*

COUNTY	ZONE	1980	1985	1990	1995	2000
7	281	12840.	13089.	13316.	13312.	13362.
7	282	12208.	12901.	13123.	13184.	13127.
7	283	31820.	33451.	34945.	36442.	37524.
7	284	20224.	20043.	19786.	19631.	19521.
7	285	12594.	13200.	13685.	14198.	14630.
7	286	12361.	12871.	13252.	13738.	14085.
7	287	9018.	8799.	8779.	8941.	9026.
7	288	15399.	15107.	15276.	15105.	15016.
7	289	16800.	17265.	17441.	17721.	17790.
7	290	13664.	14462.	15220.	15981.	16637.
7	291	15169.	19404.	19915.	20105.	20265.
7	292	16254.	17787.	18028.	18532.	18924.
7	293	26039.	27702.	30355.	33909.	35817.
7	294	20441.	21849.	21915.	22161.	22386.
7	295	11899.	13900.	19492.	20268.	20653.
7	296	47.	46.	50.	54.	57.
7	297	11117.	11605.	11587.	11581.	11608.
7	298	6247.	6245.	6320.	6365.	6443.
7	299	13846.	13691.	13343.	13297.	13424.
7	300	11240.	10963.	10652.	10568.	10577.
7	301	4638.	4521.	4390.	4412.	4463.
7	302	6044.	5944.	5826.	5778.	5816.
7	303	6814.	6651.	6466.	6431.	6460.
7	304	17519.	19215.	21223.	22288.	23100.
SANTA CLARA TOTAL		1259441.	1332691.	1418628.	1487303.	1537491.
6	305	5380.	6100.	6908.	7593.	7756.
6	306	6131.	6024.	5882.	5835.	5831.
6	307	3700.	3683.	3667.	3686.	3737.
6	308	20115.	19614.	19213.	19069.	19083.
6	309	9505.	9622.	9734.	9871.	10127.
6	310	8236.	8106.	8198.	8350.	8557.
6	311	1838.	1817.	1856.	1861.	1895.
6	312	4989.	5053.	5088.	5184.	5315.
6	313	14057.	16147.	17036.	17652.	18652.
6	314	3384.	3326.	3341.	3351.	3400.
6	315	9382.	9366.	9277.	9300.	9314.
6	316	6431.	6775.	8031.	9417.	9770.
6	317	6316.	7172.	8179.	9269.	10182.
6	318	13050.	12867.	13974.	14537.	15089.
6	319	14756.	14489.	14306.	14291.	14325.
6	320	13239.	13030.	13143.	13346.	13670.
6	321	14644.	14354.	14368.	14533.	14899.
6	322	6510.	7650.	9795.	10615.	11435.
6	323	3464.	5198.	8423.	11280.	15502.
6	324	12879.	13409.	13607.	13405.	13205.
6	325	4257.	4217.	4142.	4096.	4055.
6	326	8770.	8859.	8915.	9776.	10495.

TABLE C-2 (Cont.)

COUNTY	ZONE	1980	1985	1990	1995	2000
6	327	7733.	7613.	7549.	7510.	7535.
6	328	2882.	3090.	3189.	3224.	3280.
6	329	6662.	10013.	14824.	17882.	18293.
6	330	10566.	10206.	10254.	11317.	11785.
6	331	6054.	6513.	6456.	6683.	6852.
6	332	4759.	5218.	5172.	5424.	5614.
6	333	6799.	8391.	9580.	10016.	10691.
6	334	20050.	20281.	20202.	20175.	20239.
6	335	5230.	5197.	5668.	5646.	5627.
6	336	10611.	10299.	10039.	9893.	9749.
6	337	18222.	17932.	21029.	20767.	20509.
6	338	9808.	10738.	11017.	11135.	11402.
6	339	7183.	7072.	7958.	7978.	7985.
6	340	3753.	3684.	3662.	3666.	3707.
6	341	14446.	18865.	19448.	19218.	18936.
6	342	14351.	14077.	13881.	13678.	13451.
6	343	15892.	15798.	19962.	19917.	19871.
6	344	14436.	14000.	13671.	13495.	13326.
6	345	13861.	14135.	14231.	14483.	14769.
6	346	21591.	21997.	23477.	24856.	26436.
6	347	16564.	16520.	16175.	15925.	15675.
6	348	13338.	13132.	12904.	12799.	12722.
6	349	6923.	6809.	6911.	7026.	7276.
6	350	6727.	6739.	6640.	6548.	6707.
6	351	7354.	7273.	7170.	7120.	7088.
6	352	9354.	9323.	9148.	9017.	8953.
6	353	3824.	3750.	3737.	3738.	3760.
6	354	4505.	4449.	4482.	4450.	4489.
6	355	2607.	2575.	2551.	2520.	2509.
6	356	73.	71.	69.	68.	67.
6	357	4329.	4333.	4292.	4400.	4411.
6	358	15681.	15396.	15182.	15273.	15632.
6	359	14912.	14652.	14479.	14639.	14734.
6	360	4803.	6693.	8939.	9194.	10021.
6	361	11939.	12291.	12350.	12201.	12243.
6	362	12552.	13116.	13023.	12993.	13048.
6	363	31090.	30723.	31072.	31458.	32310.
6	364	5243.	5142.	5098.	5065.	5083.
6	365	21741.	22688.	22317.	22076.	21837.
6	366	9535.	10330.	10833.	13201.	15817.
SAN MATEO TOTAL		609017.	628004.	655723.	672993.	690730.
5	367	16219.	15612.	15378.	15404.	15433.
5	368	1542.	1477.	1447.	1450.	1461.
5	369	10372.	9882.	9613.	9501.	9408.
5	370	426.	398.	380.	369.	358.
5	371	8221.	7975.	7858.	7792.	7751.
5	372	17330.	16542.	16081.	15851.	15656.

TABLE C-2 *(Cont.)*

COUNTY	ZONE	1980	1985	1990	1995	2000
5	373	15970.	15426.	15195.	15211.	15260.
5	374	15027.	14486.	14209.	14122.	14059.
5	375	7733.	7501.	7520.	7590.	7702.
5	376	9064.	8781.	8654.	8659.	8681.
5	377	27705.	26720.	26627.	26260.	25935.
5	378	4106.	3980.	3903.	3833.	3777.
5	379	18176.	17608.	17340.	17315.	17293.
5	380	7038.	6815.	6858.	7146.	7416.
5	381	10.	9.	10.	10.	9.
5	382	6992.	7033.	7093.	7274.	7539.
5	383	7680.	7448.	7332.	7295.	7289.
5	384	1818.	1744.	1709.	1679.	1649.
5	385	13223.	12842.	12764.	12902.	13014.
5	386	9794.	9370.	9183.	9011.	8842.
5	387	17651.	17567.	17492.	17286.	17148.
5	388	7065.	7054.	7036.	7117.	7178.
5	389	8306.	8111.	8183.	8519.	8833.
5	390	8584.	8359.	8281.	8313.	8364.
5	391	10395.	10185.	10396.	10584.	10855.
5	392	6546.	6352.	6273.	6293.	6321.
5	393	5925.	5893.	5990.	6088.	6222.
5	394	14459.	14363.	14577.	14968.	15438.
5	395	9434.	9366.	9308.	9389.	9451.
5	396	11356.	11228.	11103.	11230.	11326.
5	397	19650.	19840.	20146.	21008.	21755.
5	398	12679.	12378.	12289.	12348.	12428.
5	399	7299.	7167.	7197.	7294.	7414.
5	400	17600.	17039.	16818.	16830.	16871.
5	401	9289.	9059.	9077.	9230.	9412.
5	402	16232.	16221.	16723.	17606.	18549.
5	403	14384.	14270.	14875.	15868.	16964.
5	404	49.	47.	46.	47.	47.
5	405	17387.	16986.	17223.	17739.	18330.
5	406	6227.	6073.	6092.	6220.	6366.
5	407	10040.	9820.	9876.	10048.	10255.
5	408	5114.	5044.	5062.	5197.	5383.
5	409	8386.	8237.	8324.	8499.	8706.
5	410	6430.	6346.	6349.	6394.	6457.
5	411	8794.	8553.	8827.	9232.	9705.
5	412	12225.	12159.	12502.	12698.	13014.
5	413	6887.	6666.	6654.	6849.	7029.
5	414	8512.	8200.	8098.	7986.	7883.
5	415	3431.	3326.	3350.	3352.	3416.
5	416	8296.	8051.	7949.	7860.	7782.
5	417	5719.	5571.	5510.	5456.	5408.
5	418	9803.	9644.	9573.	9528.	9493.
5	419	18519.	18000.	17742.	17554.	17382.
5	420	8895.	8585.	8390.	8274.	8165.
5	421	2201.	2103.	2036.	2001.	1969.
5	422	2105.	2021.	1962.	1928.	1894.

TABLE C-2 *(Cont.)*

COUNTY	ZONE	1980	1985	1990	1995	2000
5	423	16668.	16063.	15640.	15417.	15208.
5	424	6374.	6243.	6161.	6118.	6079.
5	425	2618.	2474.	2372.	2313.	2255.
5	426	9789.	9186.	8752.	8508.	8265.
5	427	335.	320.	311.	305.	298.
5	428	283.	271.	265.	260.	255.
5	429	2416.	2368.	2333.	2314.	2294.
5	430	1211.	1172.	1143.	1128.	1112.
5	431	74.	69.	65.	63.	61.
5	432	4118.	3941.	3854.	3782.	3712.
5	433	4064.	3978.	4043.	4248.	4440.
5	434	10965.	10518.	10256.	10073.	9893.
5	435	9283.	9043.	9058.	9305.	9532.
5	436	4117.	4063.	4100.	4140.	4181.
5	437	9108.	8864.	8815.	8859.	8900.
5	438	22086.	21747.	22221.	23168.	24068.
5	439	10372.	10392.	10396.	10544.	10669.
5	440	7066.	6932.	6987.	6931.	6877.
SAN FRANCISCO TOTAL		665271.	649175.	647254.	652982.	659843.
AREA TOTAL		5128316.	5423525.	5692822.	5965030.	6205006.

WQ Tech Memo No. 57
William F. Dietrich and John A. Davis
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LEAF REMOVAL
AS A SURFACE RUNOFF
CONTROL MEASURE

Technical Memorandum No. 57

April 9, 1980

INTRODUCTION

Falling leaves in urban areas contribute a significant organic pollutant load to stormwater runoff and receiving waters. This technical memorandum explores leaf removal as a method of reducing surface runoff pollution.

A. SUMMARY AND CONCLUSIONS

Fallen leaves contribute a substantial, though not quantified, pollutant load to storm runoff in the Bay Area. During initial leaching, leaves release nitrogen equal to one to two percent of their original dry weight and phosphorus equal to approximately a tenth of a percent of original weight. Through decomposition, leaves exert a substantial oxygen demand on receiving waters, which is equal to roughly one-half to three-quarters of their initial weight.

Leaf removal can provide water quality benefits by separating vegetative matter from runoff. The most important benefit is the reduction of biological and chemical oxygen demand. Of less significance is the control of nitrogen and phosphorus leaching. Maximum water quality benefits accrue from cleaning efforts prior to major storms. Leaf removal is a cost-effective pollution control measure, in reducing solids loadings and oxygen demand in stormwater runoff.

B RUNOFF POLLUTION FROM LEAVES

1. Leaching

According to Kaushik and Hynes (1971), water leaches most of the soluble matter from fallen leaves in three to four days of soaking. Nykvist (1963) and Hart (1975) report leaching weight losses ranging from twelve to forty-four percent of initial weight, depending on species. Leaching plays an important role in releasing nitrogen and phosphorus from leaves.

Nitrogen

Elemental nitrogen makes up a small percentage of initial dry leaf weight. Depending on species, nitrogen is 0.5 to 2.5-percent of dry weight (Gessel, 1960, as cited by Lavender, 1970, p.4; Kaushik and Hynes, 1971, pp.486-487). Triska (1975, p.9) reports leaching of over fifty percent of initial nitrogen content in four days from Douglas-fir needles, vine-maple, big-leaf maple, and alder leaves. Using this data, one could estimate that a kilogram of leaves originally containing 1.5-percent nitrogen would probably lose 7.5 grams of nitrogen after four rainy days.

Phosphorus

The percentage of phosphorus in dry leaves is generally less than the percentage of nitrogen. Cowen and Lee (1973) measured 0.07-percent P in poplar leaves and 0.1-percent P in oak leaves. Gessel (1960), as cited by Lavender (1970), reports 0.1 to 0.25-percent P in Douglas-fir needles.

Cowen and Lee have done the only available study on phosphorus leaching from leaves. Wet leaves were gathered twelve hours after a storm and soaked for an hour. The leachate contained 5.4 percent of the total P initially in the oak leaves and 21-percent of the total P contained in the poplar leaves. In terms of weight, oak leaves lost .054 grams P per kilogram of leaves.

Factors Affecting Leaching

Both the length of soaking and the number of previous soakings affect the concentration of soluble pollutants from leaves in runoff (Cowen and Lee, 1973). The longer fallen leaves are exposed to water (up to four or five days), the more soluble pollutants escape. The amount of discharge decreases with each successive leaching. Consequently, a storm lasting several days at the beginning of the rainy season removes more soluble matter from leaves than a short rain later in winter would.

Leaf texture is an important determinant in the rate of leaching and decomposition (Hart, 1975, p.9). Soft leaves leach and break down faster than tough ones.

Physical damage increases pollutant concentrations in leachate. Cowen and Lee (1973) found that cut-up oak leaves released three times as much phosphorus

as intact leaves. Burning leaves also facilitates the leaching of pollutants (Finn, 1943).

2. Decomposition

The factors affecting decomposition rates include water temperature and quality, nutrient concentrations, the numbers and species of microbial flora and predator populations (Hart, 1975, p.19).

Oxygen Demand

As leaves decompose over a period of weeks or months, they exert an oxygen demand in streams and water bodies. Chase and Ferullo (1958) found that oak leaves and pine needles consume an amount of oxygen approximately equal to 50-percent of their initial weight, while maple leaves demand about 75-percent. Slack and Feltz (1968, p.128) noted reduced dissolved oxygen levels in filtered stream water due to microbial decomposition of leaves. Their experiments also found that oxygen demand varied by species.

Maximum oxygen consumption occurs after many weeks of decomposition. Triska (1975, p.35) showed that vine-maple, Douglas-fir, and alder leaves exerted the greatest demand between 80 to 200 days after placement in a stream.

Triska estimated that approximately one-third of the oxygen consumption could be attributed to chemical oxygen demand or to populations of microbes utilizing leaves as inert surfaces for growth.

Nitrogen

The quantity of nitrogen left over after leaching doubles during decomposition (Krumholz, 1972). The increase is attributed to fungal growth (Triska, 1975).

3. Potential Runoff Pollution from Leaves in the Bay Area

Runoff pollution from leaves depends upon the weight of leaf litter, the abundance of different tree species, and the timing of leaf falls. The number of trees on city streets and in public parks in the Bay Area is roughly estimated at 2,370,000 using data and analysis from Morse (1980). This figure is a conservative estimate of the number of trees in urban areas whose leaves may be affected by leaf removal programs, since it does not include private property.

Weight of leaf fall. Forestry literature contains some data on leaf fall rates and volumes in forests (Bray and Gorham, 1964). These measurements are usually given in metric tons per hectare per year, and are inapplicable to urban areas. Data on trees per acre in forests differs by species and age, and varies between 1000 trees per acre in a young stand to 100 trees per acre in a mature stand. The ages of street and park trees depend on the age of urban areas and history of planting programs. Natural forest density and age and species distribution

are all variables in converting leaf fall in forests to leaf fall in urban areas. Due to all these unquantified factors, the range of leaf fall weights from public trees in Bay Area cities is best estimated at between 3,500 and 10,500 metric tons per year.

This estimate excludes private trees due to lack of data, and therefore underestimates the actual leaf fall in cities within ABAG's jurisdiction. Fallen leaves in rangeland, forests, and unincorporated areas within ABAG's region are also not included in this estimate. Although these leaves do pollute surface runoff, more pollutants leach into the soil in these areas than in cities where asphalt and concrete force runoff into storm sewers. The estimate also excludes rural trees because leaf removal by street sweeping or pickup is generally conducted only in cities.

Abundance of Species. Data on the abundance of various tree species in the Bay Area does not exist. Since leaves from different trees contribute varying pollutant loads, it is not possible to accurately estimate the pollution potential. Using previously described research results, the range of pollution potential is roughly estimated in Table 1.

Timing. Most deciduous leaves drop in autumn, just before and during the beginning of the rainy season. On the other hand, coniferous needles drop year-round. The heaviest loading of vegetative matter in the Bay Area occurs in fall and early winter. Since the heaviest loadings coincide with the beginning of the rainy season, much of the potential pollution from leaves may be absorbed by storm runoff.

C LEAF REMOVAL PRACTICES

Local survey results indicate that most leaf removal activities occur in fall. Government agencies collect leaves by manual and mechanical methods. The manual method entails workers raking and sweeping leaves into piles and loading the piles onto trucks. Mechanical methods include: 1) using a street sweeper alone, 2) using a street sweeper with a trash-screen mounted on the front to push leaves into piles for loading, 3) using front-end loaders to collect leaf piles or gather leaves and place them in trucks, and 4) using a vacuum truck.

Approximately half of those jurisdictions which responded to the ABAG Public Works Survey Questionnaire have a program to pickup leaves, grass, and garden clippings from residences. Pickup frequencies vary from once per week to twice per year. Most often this service is included in normal garbage collection and is performed by a private company. Residents are usually required to put leaves in bags to facilitate handling.

The weight or volume of leaves collected is not available from public agencies or garbage companies, since leaves are mixed with street sweepings or other garbage during collection. Budget figures are similarly unavailable.

TABLE 1

ESTIMATED RANGE OF POTENTIAL POLLUTION CAUSED BY FALLEN LEAVES FROM PUBLIC TREES IN ABAG AREA CITIES

NOTE: Only street and park trees are considered, the number of private trees could not be estimated.

	Range of Leaf Fall Weight m tons/yr.	Short tons/yr.	Range of Oxygen Demand 50%-75% of initial weight m tons/yr.	Range of Nitrogen 1%-2% of initial Weight m tons/yr.	Range of Phosphorus 0.1% of initial weight m tons/yr.
Low Estimate	3,500	(3,900)	1750-2600	35-70	3.5
High Estimate	10,500	(11,600)	5250-7880	105-210	10.5

NOTE: m tons/yr. = metric tons per year.

D REMOVAL COSTS

Cost data for leaf removal is not available from local public works agencies or garbage collectors. Expenditures for personnel and equipment are typically hidden within street sweeping and garbage collection budgets.

E IMPLICATIONS FOR WATER QUALITY MANAGEMENT

The decomposition of fallen leaves imposes a substantial oxygen demand on receiving waters. Removing a ton of leaves cuts the potential oxygen demand by roughly one-half to three-quarters of a ton. Therefore, cleaning programs can significantly reduce BOD and COD loadings.

The effectiveness of removal efforts in preventing the leaching of nitrogen and phosphorus from leaves is small since these pollutants are released in three to four rainy days. The greatest N and P reductions can be obtained by collecting leaves prior to major storms.

F COST-EFFECTIVENESS

As previously explained, budget figures for leaf collection are not available. The cost-effectiveness of leaf removal is estimated below, using information from field measurements, public works officials, and the Bureau of Labor Statistics.

The cost-effectiveness of collecting bagged leaves from residences depends upon the weight of the leaves and the cost of pickup. The bag weight varies with the type of leaves and the size of the bag. Samples of oak and eucalyptus leaves and Ponderosa pine needles were weighed and measured to determine their densities. The samples ranged from 4.7 pounds per cubic foot (lbs/cu.ft.) to 6.2 lbs./cu.ft., with an average of 5.5 lbs./cu.ft. Based on this average, a 30 gallon (4 cu. ft.) bag would contain approximately 22 lbs. of leaves. Oakland Scavenger Company picks up a bag of leaves for a 95 cent charge to the customer (Cunha, 1980). Therefore, the cost-effectiveness of leaf collection is approximately 23 lbs. per dollar. In terms of reduced biochemical oxygen demand, the benefit is 12 to 17 lbs. per dollar.

A leaf vacuum truck, like the one in Hayward, California (Souza, 1980), picks up an estimated 29 cubic yards of leaves per day, during the leaf season. Using winter 1980 figures for wages and equipment costs, the cost-effectiveness of vacuum removal is conservatively estimated as approximately 18 lbs. of leaves per dollar expended. The benefit in terms of reduced oxygen demand is approximately 9 to 14 lbs. per dollar.

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WQ Tech Memo No 58
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LITTER CONTROL
AS A SURFACE RUNOFF
CONTROL MEASURE

Technical Memorandum No. 58

April 9, 1980

INTRODUCTION

This technical memorandum investigates litter control as a method of reducing surface runoff pollution. Litter is defined as solid waste discarded or improperly deposited by human beings. Litter contributes to runoff pollution when it degrades in the presence of rainwater or washes from sidewalls, streets, highways, and parks into stormwater collection systems and subsequently into receiving waters.

This memorandum utilizes data from local and regional litter surveys and telephone interviews with local public works officials. In addition, the available literature in several technical libraries provides theoretical and empirical background information.

A SUMMARY AND CONCLUSIONS

It is estimated that 300 million items are littered in the Bay Area each year. An unknown portion of this debris washes into storm sewer systems, contributing solid loadings. Paper products, which make up approximately one-half of all litter, decompose in runoff or receiving waters and decrease dissolved oxygen levels. This oxygen demand is not quantified.

Litter control can reduce these pollutant loadings in surface runoff. Methods of control include clean-up programs, providing trash receptacles, using litterbags, and sweeping streets. Educational programs, positive economic incentives, and law enforcement are ways of changing littering habits.

The effectiveness of litter control in reducing water pollution cannot be estimated, due to lack of information. Litter receptacles and litter clean-up programs are as cost-effective as street sweeping in removing the solids available to storm runoff, but are not necessarily as cost-effective in reducing pollutant loadings (based on Alameda County data).

B RUNOFF POLLUTION FROM LITTER

The contribution of litter to runoff pollution depends upon the amount of litter, its composition, and the pollutant contents of its various constituents.

Amount. The volume of litter exposed to rainwater is determined by generation rates and the frequency and effectiveness of cleaning programs. Daniel B. Syrek, a nationally-known litter expert, developed base-line data on debris scattered in Alameda County (1979) which is shown in Table 1. Syrek estimated the total items littered in Alameda County at approximately 155 million per year. In 1975, Syrek estimated litter generation rates on streets and highways for other counties in the Bay Area, as shown in Table 2.

Composition. The components of litter in Alameda County are shown in Table 3. The data indicate diverse sources and differences according to land use. For more detail, Table 4 shows the makeup of litter throughout California in 1975. The two sets of survey results are very similar except that there is much more unidentified litter in the Alameda counts. Also evident is the elimination of pull tabs from beverage cans since 1975.

Pollutant Contents. Considering the components of litter, approximately 29 percent, by weight, are paper products, e.g. packaging and newspapers, which decompose rather quickly. These materials exert a biochemical oxygen demand on runoff water, and if they enter storm sewer systems, on receiving waters. Soft drink and beer containers make up approximately 40 percent of litter by weight. These and other non-biodegradable components, such as vehicle parts, plastics, and construction debris add to total solids loadings if they wash into storm sewers.

Empirical data on pollution from litter is scarce and incomplete. The American Public Works Association (1969) analyzed pollutants in the dust and dirt fraction of litter samples collected in Chicago. Particles passing through a hardware cloth (1/8th inch sieve) were mixed with sterile water in a blender. The mixture was filtered, and pollutant concentrations of only the soluble fraction were measured. Table 5 shows the average pollutant concentrations according to land use.

These figures estimate the maximum pollution potential from particles less than 1/8th inch in size on city streets. Most of this material is dust and dirt, some may be fragments of litter, such as torn paper and broken glass. The AWPA study did not attempt to estimate the pollution potential of insoluble litter particles or street litter larger than 1/8th inch in size.

An estimate of the pollutant contents of total litter would require more data. Water pollution from litter is not comparable to pollution from refuse dumps or landfills since the composition of litter differs from municipal solid waste (Darlington) 1969.

TABLE I
ALAMEDA COUNTY 1979 BASELINE LITTER RATE DATA

Locale	Fresh Litter: Items Per Mile-Week	Fresh Litter: Square Feet Per Mile-Week	Accumulated Litter: Items Per Mile	Accumulated Litter: Square Feet Per Mile
Rural Roads & Highways				
Freeways	919	167	25,832	2,609
Other State Highways	464	68	13,238	1,676
County Roads	313	53	6,185	979
Urban Streets & Freeways				
Freeways	3,181	740	62,220	10,092
Vac./Indus./Utility	1,857	217	36,762	3,044
Commercial	1,712	157	11,555	588
Public Bldg./Park	692	65	8,008	436
Residential	675	55	4,146	229
Other				
Recreation Areas	1,958	269	7,861	1,079
Drainage Channels	242	42	4,522	869

"Items per mile-week" means the number of items which were discarded during one week on a mile-long stretch of road.

"Square feet per mile-week" refers to the area these items take up when placed side by side on the ground. This measure indicates the aesthetic impact of litter.

SOURCE: Syrek, 1979, p.4.

TABLE 2

County	Estimated Annual Items Littered on Streets and Highways (Millions) 1975 Data
Alameda	80.4
Contra Costa	55.3
Marin	25.3
Napa	17.1
San Francisco	29.1
San Mateo	50.8
Solano	34.6
Sonoma	41.8
BAY AREA TOTAL	334.4

Source: Syrek, 1975, pp.196-19.

TABLE 5

COMPOSITION OF FRESH LITTER
Item Count Percentage

Product/Pkg.Group	Alameda County Average	Rural Rds.& Hwys. Freeways & Other State Highways	Rural Rds.& Hwys. County Roads	Urban Sts.& Fwys. Fwys.	Urban Sts.& Fwys. Vac./Ind./Util.	Urban Sts.& Fwys. Comm.	Urban Sts.& Fwys. Pub. Bldg./Park	Urban Sts.& Fwys. Res.	Other Recr. Areas	Other Drain. Chan.
Beer & Soft Drnk.Cont.	3.5%	4.5%	16.1%	2.9%	4.2%	3.1%	3.9%	2.9%	5.9%	7.4%
Juice,Wine,Liq.Cont.	.6	.5	.7	.3	.8	1.0	1.0	.5	1.0	.7
Bottle Caps	2.8	-	1.4	1.4	1.6	3.7	4.5	3.0	5.6	1.7
Pull Tabs	.9	1.7	.5	.2	.2	1.2	2.0	.5	2.5	2.2
Cups,Lids,Straws	8.9	8.3	8.0	5.3	8.2	13.7	8.1	9.5	13.1	11.9
Carriers,Cartons,Etc.	1.4	-	1.6	.9	.9	1.1	.4	4.1	.9	.8
Candy,Gum,Snacks	12.9	6.7	16.0	5.5	14.5	18.0	19.6	19.2	17.1	8.8
Take-Out Food	1.3	1.0	2.0	.9	1.0	2.4	2.9	1.1	.5	5.3
Cigarette Pkg.Match Bks.	7.4	8.4	3.9	4.9	6.9	11.6	9.8	8.3	6.4	4.5
Napkins,Tissues,Bags,Etc.	11.2	17.9	12.2	9.8	13.6	12.0	9.3	8.0	17.4	3.6
Newspapers,Magazines	2.5	3.6	2.2	2.8	1.0	.6	2.6	3.3	3.9	1.3
Advertising	.6	.5	.2	.7	.3	.6	.6	.4	.4	.2
Toiletries,Clothing,Toys	2.5	1.8	5.3	2.7	4.2	1.7	2.0	2.5	2.8	.6
Food Pkg.,Milk Cartons,Etc.	4.8	5.9	3.0	3.2	5.3	3.6	4.7	6.7	8.6	2.3
Vehicle Debris,Supplies	3.1	6.6	3.9	6.6	1.6	1.2	.1	.6	.1	.3
Construction Debris,Etc.	2.6	1.8	.2	5.2	.3	1.9	1.1	.6	-	1.1
Other Products/Unident.	33.2	30.9	23.0	46.7	35.4	22.8	27.6	29.1	13.9	47.4
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

All data is based on fresh litter rates adjusted to Alameda County average traffic volumes, neighborhood income, etc. Take-out food packaging does not include cups, lids, straws, etc. classified in other groups. About 20% of other products/unidentifiable are other miscellaneous products; the balance is unidentifiable paper, plastic, metal, glass, etc.

Source: Syrek, 1979, p. 20.

TABLE 4

COMPOSITION OF CALIFORNIA LITTER

Item Count Percentage
(Not Weight)

Basic Convenience Product Litter	Average For State
Candy, Gum, Ice Cream, Nuts, Cookies, etc.	16.56%
Pull Tops	10.95
Cigarettes, Cigars, Matches, Tobacco, etc.	10.07
Cups, Lids, and Straws	7.91
Beer Cans, Bottles, Crowns, Carriers	6.99
Napkins, Facial & Toilet Tissue, Paper Towels	5.56
Soft Drink Cans, Bottles, Crowns, Carriers	4.05
Paper Bags, Sandwich Wrap, Picnic Plates, Coolers	3.50
Take-Out Food Packaging (Hamburger, Fries, etc.)	2.02
Juice, Wine & Liquor Cans, Bottles	1.28
Plastic Carriers & Other Unident. Beverage Litter	.65
	69.54%
Other Products and Materials	
Forms, Tags, Instructions, Bills, Stationery Supplies	4.11%
Miscellaneous Paper, Cardboard Packaging & Wrapping	1.98
Vehicle Parts, Supplies, Debris, Forms	1.65
Food Packaging	1.76
Plastic Bottles, Tubs, Rubber Products	1.57
Advertizing - Handouts, Coupons, Business Cards, Signs	1.21
Furniture, Construction Debris, Wood, Rope, etc.	1.17
Newspaper	.99
Toiletries/clothing	1.84
Toys, Sporting Goods, Photo Supplies	1.07
Food Remnants	.45
Magazines, Books, Pornography	.18
	17.98%
Other Litter - Product Source Unidentifiable	
Paper - Miscellaneous Small Pieces	3.58%
Plastic - Miscellaneous Small Pieces, Tape, Bags	3.79
Glass Bottles and Pieces	.41
Other Glass and Ceramic	.54
Metal Cans, Foil, and Other	4.13
	12.45%
	100.00%

Source: Syrek, 1975, p.51.

TABLE 5

POLLUTANT CONCENTRATIONS IN THE SOLUBLE FRACTION OF DUST, DIRT, AND LITTER PARTICLES LESS THAN 1/8TH INCH IN SIZE ACCORDING TO ADJACENT LAND USE

NOTE: Litter samples from Chicago streets, 1969.

ITEM	LAND USE		
	Single Family	Multiple Family	Commercial
Water Soluble (mg/g)	6.0	5.6	12.4
Volatile Water Soluble (mg/g)	3.8	3.4	6.9
BOD (mg/g)	5.0	3.6	7.7
COD (mg/g)	40	40	39
PO_4 (mg/g)	.05	.05	.07
N (mg/g)	.48	.61	.41
Total plate counts/g (x 1000)	10,900	18,000	11,700
Confirmed coliform/g (x 1000)	1,300	2,700	1,700
Fecal enterococci/g	645	518	329

SOURCE: American Public Works Association, 1969, p. 55.

C LITTER CONTROL METHODS

Clean-up Programs. Litter cleanup is undertaken by volunteers (individually or in citizen groups), juvenile traffic offenders (in Contra Costa County), inmate collection crews, or paid public works staff. Some jurisdictions use a specified period of pickup for litter violations. Among these variations the most continuous effort is made by inmates and public works staff. Currently, Sheriff's Departments in Contra Costa and Solano Counties manage inmate crews.

Litter Receptacles. If trash receptacles are plentiful enough for convenient pedestrian use, they can significantly reduce litter. Finnie (1973) demonstrated decreases of 15 to 17 percent in commercial areas. Containers placed on roadsides and litterbags in cars can reduce highway litter. Street receptacles must have small openings and locking lids to discourage people from using them for disposal of household garbage (Zonino, 1980). San Francisco uses a concrete container which incorporates these features (Roumbanis, 1980).

Street Sweeping. Approximately one-half of litter lies on streets and highways; the remainder rests on sidewalks and adjacent areas (Syrek, 1975, p.29). Since many road miles lack curbs, they cannot be mechanically swept. Syrek (1975, p.102) estimates that only about 20-percent of California litter collects between curblines where sweepers can remove it. There is insufficient data to evaluate increases in sweeping frequencies in capturing litter before it enters storm sewers.

Education. Seventy-five percent of littering involves a deliberate conscious act. The most frequent offenders are young males who discard convenience packaging (Public Opinion Surveys, 1968). Programs in some elementary, grammar and high schools strive to create negative peer group attitudes toward littering. Media campaigns and public participation in litter clean-up events also publicize the need for litter abatement. The effectiveness of these educational programs in reducing litter generation rates is unknown.

Positive Economic Incentives. Monetary rewards for returned beverage containers work well in Oregon and other states with mandatory deposits on beer and soda cans and bottles (California Public Interest Research Group, 1979). Clark (1971) demonstrated this effect by offering money to children for picking up litter in parks and using litterbags in theatres. Except for beverage containers, monetary rewards cannot easily be applied to litter items in urban settings.

Law Enforcement. Frequent warnings and citations for acts of littering can produce a credible deterrent over a short period of time in small neighborhoods (Feld, 1978). Best results are obtained when persons with police power issue citations directly (Snell, 1980). Educating and involving law enforcement personnel is a key to achieving convictions. Detailed ordinances concerning illicit dumping, proper garbage containers, vehicle load coverings, construction debris, and loading/unloading operations are essential (cf U.S. Brewers Association, Inc., undated).

At this time, Contra Costa and Solano Counties have the only designated Litter Control Officers in California (Snell, 1980). San Francisco maintains an Environmental Control Officers Program in which ten CETA workers issue about 1,000 citations and many more warnings annually (Roumbanis, 1980). The effectiveness of enforcement in altering litter habits has not been evaluated.

D IMPLICATIONS FOR WATER QUALITY MANAGEMENT

There is insufficient data to analyze the relationship between litter accumulation and impacts on water quality. The effectiveness of various methods of litter control in reducing water pollution cannot be ascertained.

E COST-EFFECTIVENESS

Since the pollutant contents of litter are not known, it is not possible to estimate costs per pollutants removed. Costs per solids removed can be estimated for litter receptacles and clean-up programs.

Litter Receptacles. Calculations based on ABAG and telephone survey results indicate an average annual cost for emptying receptacles of $110. The range is from $50 to about $200. The cost per container pickup, including disposal, ranges from $0.48 to approximately $2.00, with an average of $1.34. Variability is largely due to differences in accounting procedures. Litter receptacles with locking lids cost between $175 to $240 (Lindley, 1980; Roumbanis, 1980). Useful life is about 5 years (Syrek, 1975; Roumbanis, 1980).

The contents of 40 standard-size litter receptacles in Berkeley, California, were weighed by Alameda County Flood Control District staff in May, 1980. The containers were selected at random from commercial districts and measured on a single day. The average weight of litter was 6.8 lbs.; the average volume of litter, 1.6 cu.ft. (Lindley, 1980). If 100 percent of the container contents is litter, the cost-effectiveness based on the above data ranges from 3 to 11 lbs. of solids removed per dollar expended. The maximum cost-effectiveness, for a full 30 gallon receptacle, ranges from 8 to 26 lbs. per dollar. These estimates assume daily pickup in Berkeley, but this assumption is not verified.

Although the District staff estimated that most of the receptacle contents in Berkeley were litter, public works officials in other jurisdictions reported that household garbage is frequently dumped into receptacles. For containers without locking lids and small openings, more than half the contents is usually household garbage (Zonino, 1980; Roumbanis, 1980). Even for well-designed containers in cities with mandatory garbage service, the addition of garbage to litter increases disposal costs and reduces the cost-effectiveness of litter receptacles.

Clean-Up Programs. Data from Contra Costa County in 1975, shown in Table 6, reveal the relative cost efficiency of inmate crews and paid public agency workers. Highway cleanup efforts cost more than urban cleanup due to travel expenses.

Assuming equivalent amounts collected and inflating budget costs to 1980 dollars (to compare with Tech. Memo 38), pick-up program cost-effectiveness values are 11 lbs./$ for inmate programs, 7 lbs./$ for public works agencies and 4 lbs./$ for Cal Trans.

Conclusion. According to Technical Memorandum No. 38, as revised by Peter Russell, street-sweeping in Alameda County picks up between 1 to 10 lbs. of solids per dollar expended. Compared to street sweeping the cost-effectiveness ranges of litter receptacles and clean-up programs are similar. On the other hand, the pollutant contents of street dirt and litter are probably not similar. Therefore, a valid comparison is not possible. Litter control methods are important in reducing litter on areas adjacent to the street which cannot be reached by street sweepers.

TABLE 6

COST-EFFECTIVENESS OF LITTER CLEANUP PROGRAMS
1975 DATA - CONTRA COSTA COUNTY

Agency	Total Expenditures	Amount Collected	Cost per Ton	lbs. Removed per Dollar
Inmate Crew	$ 36,310	263 tons	$138/ton	15 lbs/$
Cities-Public Works	139,960	635 tons	$219/ton	9 lbs/$
Cal TRANS	66,930	162 tons	$413/ton	5 lbs/$

Source: Snell, 1980

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WQ Tech Memo No. 59/May 1980
E. Chan

ASSESSMENT OF EROSION CONTROL COSTS TO LOCAL GOVERNMENTS AND PRIVATE SECTOR

Technical Memorandum No. 59
May 15, 1980
Revised May 23, 1980

I. INTRODUCTION

Problem Statement

Erosion, sedimentation and stormwater runoff constitute a major water quality problem in the Bay Area. Eroded soil makes streams turbid, covers fish spawning beds, clogs streams and reduces reservoir capacity. Twenty-eight percent of the reservoirs in the Bay Area are identified as having sedimentation problems (Eilers et.al. 1977). The actual number affected is probably much greater. Most of the $7 million currently recorded as spent on lake and inland waterways improvement is related to this problem. Technical Memorandum No. 55, "Erosion-related Water Quality Problems" (Jackson 1980) reviews locales in the Bay Area affected by erosion and sedimentation along with clean-up and repair costs experienced by local communities.

A Solution: Grading Ordinances and Erosion Control Plans

The foundation for erosion and sediment control from construction sites will normally be a city's or county's grading ordinance. This ordinance sets the legal basis for regulating erosion and sedimentation. It generally provides that for grading activities greater than some specified minimum, the developer or landowner must devise a grading plan, seek a grading permit, perform the operation in a relatively regulated way--and possibly even post a bond which the local government can use to correct violations if the work is not undertaken in a satisfactory manner. Under the 1980 Water Quality Management Plan, ABAG is seeking methods for improving grading ordinances to ensure water quality protection.

An additional measure that helps to ensure erosion and sediment control from construction is an "erosion control plan" as part of the grading permit application. In the erosion control plan, each developer must provide detailed specifications showing how erosion will be controlled on a project site. The specifications provided by the developer should be equal to or surpass the standards and specifications found in a locally adopted Manual of Best Management Practices (ABAG has recently prepared the "Manual of Standards for Surface Runoff Control" for public use).

Model Erosion and Sediment Control Ordinance

As part of the ABAG Manual of Standards, a model ordinance was developed and presented in Technical Memorandum No. 47--"Model Grading and Erosion Control Ordinance" (Moy 1980). Requirements for the recommended features in the model ordinance can be amended to the local grading ordinance and administered through existing planning and grading departments. Table 1 summarizes the recommended features.

For projects which require grading permits, many of these items will have been previously prepared and submitted--such as the site map, grading plan, soil report, work schedule and security. New additions would be the requirements for interim and/or final erosion control plans, a revised work schedule to reflect erosion control activities and additional security, as applicable, to cover the additional erosion and sediment control costs. The erosion control plans can, in many cases, be incorporated with the grading plan to clarify the grading schedule and reduce duplication of effort. Thus, with advance planning, implementing effective erosion controls becomes an increment in cost and effort to a grading plan rather than an entirely new plan that must be prepared separately.

Purpose of this Memo

Communities which choose to attack their erosion and sedimentation problems through revising their grading ordinance and enforcing the implementation of control measures during construction, will encounter many technical, fiscal and economic questions. The most critical being how much does it cost and who ends up paying for it? The cost of preparing an erosion control plan and implementing the specified control measures is typically borne by the developer and redistributed to the consumers who invest in the project (e.g., the homebuyers in a residential development). The objectives of this technical memorandum with relation to the enactment and enforcement of effective erosion and sediment control in grading ordinances, are:

- to assess fiscal effects on local governments;
- to assess economic effects upon the private sector;
- to assess potential erosion-related economic liabilities of projects such as costs for sediment clean-up, soil replacement and indirect damages;
- to compare costs of projects with erosion control against projects without erosion control; and
- to assist local governments in evaluating the potential fiscal and economic effects of improving their grading ordinance and control program

After review by the Advisory Committees and other interested persons, this material will become part of the Environmental Assessment of the 1980 Water Quality Management Plan.

TABLE 1

RECOMMENDED FEATURES
EROSION AND SEDIMENT CONTROL MEASURES*

Component	Features
Site map	o Accurate and appropriate contour intervals o Property/site boundaries o Existing vegetation
Grading Plan	o Existing/proposed drainage facilities o Location/volumes of excavations, fills and storage o Vegetation removal and methods o Location of sediment/erosion control devices
Interim erosion control plan	o Calculations of maximum runoff and sediment yield o Specifications (where required) for: vegetative measures, erosion control devices and sediment retention structures o Reference to approved handbook/manual on erosion control o Cost estimate for erosion control measures
Final erosion control plan	o Where a final erosion control plan is required, see features under "Interim erosion control plan"
Soil report	o Where a soil report is required (e.g. for foundations and retaining walls), it should include analyses of soil conditions and recommendations for grading and erosion control
Work schedule	o Grading schedule o Site condition on July 15, Sept.1, Oct.1 and Oct. 15 o Implementation of interim/final erosion and sediment control measures o Construction schedule (as applicable)
Security/Enforcement	o Bond/deposit/letter of credit to cover cost estimate of erosion/sediment control measures o Compliance inspections and stop work orders

*Based on Tech Memo No. 47 - Model Grading and Erosion Control Ordinance (Moy 1980)

II. SUMMARY

Based on an analysis of erosion/sediment control and other potential costs experienced for construction projects, the following conclusions can be drawn. The cost estimates for erosion control apply where it is a new component of construction costs.

1. The inclusion of erosion/sediment control measures into projects where a grading plan is being prepared usually represents only a modest increase in overall project costs.

2. Local government costs to conduct an erosion and sediment control program can be effectively recovered through permit fees. The recommended fee schedule is: $50 for projects disturbing less than 25,000 square feet of land, $.002/square foot disturbed for projects affecting from 25,000-100,000 square feet; and $.001/square foot for projects disturbing over 100,000 square feet.

3. Private industry costs for implementing erosion control plans and measures will range from approximately $250 to $550 per housing unit on hillside projects and less than $250/unit in flat to gently sloping areas.

4. Given that appropriate erosion control measures are incorporated into the grading plan, the next most critical determining factors are the timing of installation and scheduled enforcement by grading inspectors.

5. While cost estimates for erosion control were not developed for single family residences and very small projects, it is estimated that erosion control costs in the same order as stated above would be applicable for small projects when performed in conjunction with grading work.

6. For sites with heavy to severe erosion due to construction, sediment runoff can exceed the open space/agricultural background condition by 4 to 23 times. The direct costs of downstream sediment removal and on-site replacement costs would exceed clean-up for background condition costs about 6 to 32 times. Indirect costs for repairing property damage and loss of environmental resources could increase costs several times more.

7. For construction sites with effective erosion controls, the sediment runoff would be reduced to approximately one-half the background rate. The direct costs of putting in control measures, sediment removal and on-site replacement would be about six times the cost to clean-up sediment emissions from background generation. However, indirect costs for environmental and property damage would be very low compared to uncontrolled construction.

8. With the addition of indirect costs, construction without erosion controls can incur a higher economic liability than projects with erosion controls. In the choice of where the most benefit is achieved per dollar spent, construction with effective erosion controls would be the recommended course of action.

III. LOCAL GOVERNMENT COSTS

For each local jurisdiction that plans to implement an erosion and sediment control program, cost estimates would be made in the following categories:

- o preparation and adoption of erosion and sediment control ordinances
- o setting up erosion and sediment control program, including training plan reviewers and inspectors
- o conducting an erosion and sediment control program
- o program revenue through permit fees

The following section discusses methods for estimating the amount of effort needed to run a program and the potential program costs and fees. Erosion and sediment control are currently practiced in some jurisdictions as a part of the public works or flood control district activities. These controls are often directed on a case-by-case basis making it difficult to estimate labor and costs on an average basis. In addition, time is usually not recorded on a project-by-project basis. Thus, data from other jurisdictions outside the Bay Area with well-functioning control programs can aid in the accessment of local control costs. The following section presents recent data from Montgomery County, Maryland, and projections for Solano County, California.

Case Study--Montgomery County, Maryland

In 1972, Montgomery County, Maryland enacted a comprehensive sediment control ordinance with nearly all of the features described in the model ordinance reviewed in Table 1. The general activities of the program include:

- o sediment control plan review and permit processing for all urban land disturbing activities
- o field enforcement of sediment control requirements
- o investigation of complaints

Background--Montgomery County covers about 316 square miles of flat and rolling terrain. The 1979 population was approximately 595,000. Montgomery County contains the communities of Bethesda, Silver Spring, Rockville and Potomac; all suburbs of Baltimore/Washington, D.C. The area is relatively urbanized and single family homes are predominant. The construction season is spring through summer with intermittent high-intensity storms that can cause significant erosion damage. Due to the frequency of spring/summer rainfall, the implementation of erosion control measures are important during construction to protect the site and surrounding environment.

Sediment Control Program--Within the County, a sediment control program has been conducted over the last nine years with relative success. The

cost to develop the program, $162,000, consisted of approximately one person-year of effort for drafting and adopting the ordinance and eight person-years for hiring and training staff. (The program began with eight inspectors.) The County was able to provide data on the effort required to conduct the program with estimates of time spent per size of project given in Table 2.

Each permit requires, on the average, 14 inspections per year to insure good control. This average takes in account that large projects with sediment basins require seven inspections per basin, weekly or bi-weekly inspections during rough grading operations, and monthly in-spections when rough grading ceases to insure measures are maintained in working order. On the other hand, small land disturbing activities require as few as two inspections.

Program Budget--The total operating budget of the sediment control section is approximately $180,000/year. This covers two plan reviewers, one chief inspector and five inspectors. In fiscal year 1979, the section reviewed 1289 sediment control permit applications, issued 911 permits and collected approximately $168,000 in fees. A more detailed description of the program, the plan review and permit process, and field inspection requirements is presented in Appendix A.

Applications for Bay Area-- Although Montgomery County has few steep or moderately sloping areas, the frequent spring/summer rainfall re-quires erosion control measures and periodic inspections to monitor erosion control. Thus, projects in Montgomery County might be inspected more frequently than similar Bay Area projects. On the other hand, terrain considered critical for construction in Maryland (greater than a 10% slope) is often built on in the Bay Area. The dry summer climate and distinct fall-winter rainfall season in California make inspection for erosion control measures most critical in September through April and relatively unimportant at other times. Thus, the inspection schedule in Montgomery County could be applicable to the Bay Area.

Proposed Erosion Control Program, Solano County

Solano County enacted in January 1980 a revised grading ordinance call-ing for: the preparation of erosion control plans to protect sites and downstream water quality; and periodic inspections to enforce the im-plementation and maintenance of erosion control measures. The program was newly developed and has no records of actual performance. The public works department has prepared a tentative fee schedule as shown in Table 3. The fee schedule is under review and has not yet been adopted. Estimates of public works staff time to process the new grading permit program are presented in Table 4. In all categories except "less than 150 cubic yards moved," the permit fee covers the actual expenses.

For Solano County, estimates of staff time were based upon each project being reviewed and inspected individually. The volume of construction is low compared to other parts of the Bay Area where a grading inspector could perform numerous inspections in one trip.

Ordinance Drafting and Adoption

New Ordinance--The effort required to draft and adopt a sediment control

TABLE 2

MONTGOMERY COUNTY SEDIMENT CONTROL SECTION

ESTIMATED STAFF TIME PER PROJECT

(FISCAL YEAR 1979)

	Housing Units/Project				
	1 unit	2-10 units	10-50 units	50-100 units	100+ units
Percentage of projects	55	8	21	12	4
Sediment control plan review time/project	.25 hr.	2 hr.	4 hr.	10 hr. (8-12 hr)	16 hr. (8-16 hr)
Average no. of inspections/project	4	6	12	20	30
Average time/inspection	.25 hr.	.5 hr.	.75 hr.	1 hr.	2 hr.
Total staff time/project	1.25 hr.	5 hr.	13 hr.	30 hr.	76 hr.
Processing fee/square foot of disturbed area	$40 minimum	$.002 ($87/acre)	$.002 ($87/acre)	$.002 ($87/acre)	$.002 ($87/acre)
Fee range/project*	$40	$40-200	$200-1,000	$1000-2000	$2000+
Average fee/housing unit	$40	$20	$20	$20	$20

*Estimated area disturbed per unit = 10,000 square feet. For developments larger than 50 units, housing density per acre increased greatly due to the high proportion of condominium and apartment units. A typical condominium would be 20 units/acre or ~2200 square feet/unit.

Source: Seely and Boswell 1980.

ordinance depends upon whether the ordinance is a new regulation to be adopted by a jurisdiction, or an amendment to be added to an existing grading ordinance. In the case of Montgomery County, Maryland, no previous ordinance relating to construction grading and erosion control existed. The effort to draft a new ordinance and follow it through adoption was about twelve person-months.

Amendment to Existing Ordinance--The majority of the jurisdictions in the Bay Area possess a grading ordinance based on Chapter 70 of the Uniform Building Code or local policies (Fitting, 1979). The major failing of most of these local ordinances is the lack of water quality protection as an objective. Most ordinances give local officials unguided discretion in determining the standards and practices necessary for compliance.

Potential improvements to local grading ordinances for effective erosion and sediment control were compiled by ABAG and presented in Technical Memorandum No. 47--"Model Grading and Erosion Control Ordinance." This model ordinance was prepared in a manner that lended itself for amendment to existing grading ordinances. The purpose was to prepare a workable program that could be adapted to all jurisdictions in the Bay Area. This would ease local efforts by reducing the time and research to prepare a similar document. Solano County, which recently amended its grading ordinance to include erosion control provisions, expended approximately 4-5 person-months of planning staff effort, including public hearing time.

Program Development

The size of an erosion control program will vary with size of the jurisdiction and the level of construction activities within its area of influence. To estimate the personnel required to conduct a program. the following steps should be performed:

1) prepare inventory of annual number of projects by size category (e.g., 1-unit, 2-10 units, 10-50 units [including schools and commercial], 50-100 units [including shopping centers], 100+ units)

2) estimate average review time by category

3) estimate number of inspections and average time/inspection by category

4) for each category, calculate staff time per project and per each category and total for all categories

5) divide summation of plan review and inspection staff times by a monthly or annual rate to determine the monthly or yearly labor requirement. Typical staff time would be 48 weeks/year. In Montgomery County, actual inspection was only conducted 40 weeks/year due to climate.

Table 5 presents some representative labor estimates derived from Montgomery County data with some modifications based on consultation with local grading and public works departments.

TABLE 5

EXAMPLE BAY AREA EROSION CONTROL PROGRAM

PROJECTED STAFF TIME

	Housing Units/Project				
	1 unit	2-10 units	10-50 units	50-100 units	100+ units
Annual no. of projects (to be filled in by local jurisdiction)	a	b	c	d	e
Average no. of units/ project	1	6	30	75	200
Erosion control plan review time/project	1 hr.	2 hr.	4 hr.	16 hr.	20-40 hr.
Average no. of inspections/project	4	6	12	20	30
Average time/ inspection*	.5 hr.	.5 hr.	.75 hr.	1 hr.	2 hr.
Total staff time/ project	3 hr.	5 hr.	13 hr.	36 hr.	80-100 hr.
Total staff time/ size category	a x 3 hr.	b x 5 hr.	c x 13 hr.	d x 36 hr.	e x 80-100 hr.

*Includes travel and inspection time; estimate assumes that several inspections are made in each trip. Staff time for travel may vary for very large jurisdictions (e.g., counties).

Plan reviewers should have training in soil mechanics and engineering. Erosion control inspectors should have several years experience in erosion control, regulatory enforcement work or other applicable and responsible work would be preferable. During winter months, the inspectors should be urged or required to receive classroom training in field inspection procedures, enforcement procedures and vegetative stabilization.

A discussion of training programs and their costs is given in Technical Memorandum No. 51--"Assessment of Construction Inspection and Inspector Training Programs" (Chan, 1980). Few jurisdictions conduct regular progra to train their erosion control personnel. The Bay Area Council of Resource Conservation Districts holds annual soil workshops for their personnel. Solano County has just initiated a workshop program for its county grading inspectors (May 1980). Clearly, if many communities are interested in upgrading their public works staff on erosion control methods, then a large scale training program--by county or for the Bay region--can be considered. Technical Memorandum No. 51 explores a regional training program and proposes that ABAG prepare and conduct such a program in 1980-81. The development cost would be $96,000 and would be funded by Federal 208 funds. This reduces the training burden of local jurisdictions. Local costs would be personnel time, travel expenses, and the use of facilities, if any.

Permit Fees/Cost Recovery

To make the erosion and sediment control program self-sufficient, it must collect enough fees to cover program administration, staff costs (labor time and expenses) to review erosion control plans and inspect projects, and other enforcement work as necessary.

Based on Table 5, an average staff cost to process a project is calculated in Table 6. Larger projects require more staff time, but also cover a larger area. The most equitable system would be to charge projects based on the area disturbed. This results in a per square foot cost in 1980$ of $.00058-$.0043. Four things may alter this range: (1) the decision by the local jurisdiction on whether to enforce all single-units or only those deemed "critical"; (2) project inspection will occur less than 52 weeks in the year (e.g. 40 weeks/year in Montgomery County) requiring extra carry-over time for inspectors; (3) travel expenses for inspection trips; and (4) the inflation rate.

The processing cost per square footage disturbed is graphed in Figure 1. To achieve cost recovery for plan review and inspection of projects, the fee shcedule shown in Table 7 is recommended. Permit fees should be updated and increased annually to reflect ongoing inflation.

TABLE 6

PROCESSING TIME AND COST

	Housing Units/Project				
	1 unit	2-10 units	10-50 units	50-100 units	100+ units
Average no. of units/ project	1	6	30	75	200
Processing time/ project*	3 hr.	5 hr.	13 hr.	36 hr.	80-100 hr.
Processing cost/ project**	$43	$72	$187	$519	$1154-1442
Area disturbed/ project (square feet)***	10,000	60,000	300,000	750,000	2,000,000
Processing cost/ square footage disturbed	$.0043	$.0012	$.00063	$.00069	$.00058-.00072

* Plan review and inspection time, from Table 5.
** Assumes staff cost of wage + benefits + overhead $\simeq$$30,000/yr. or $14.42/hr.
*** Estimated area disturbed/unit = 10,000 square feet.

TABLE 7

RECOMMENDED PERMIT FEES*

Area Disturbed	Permit Fee
less than 25,000 square feet	$50
25,001 - 100,000 square feet	$.002/square foot
greater than 100,000 square feet	$.001/square foot

*based on processing cost curve in Figure 1.

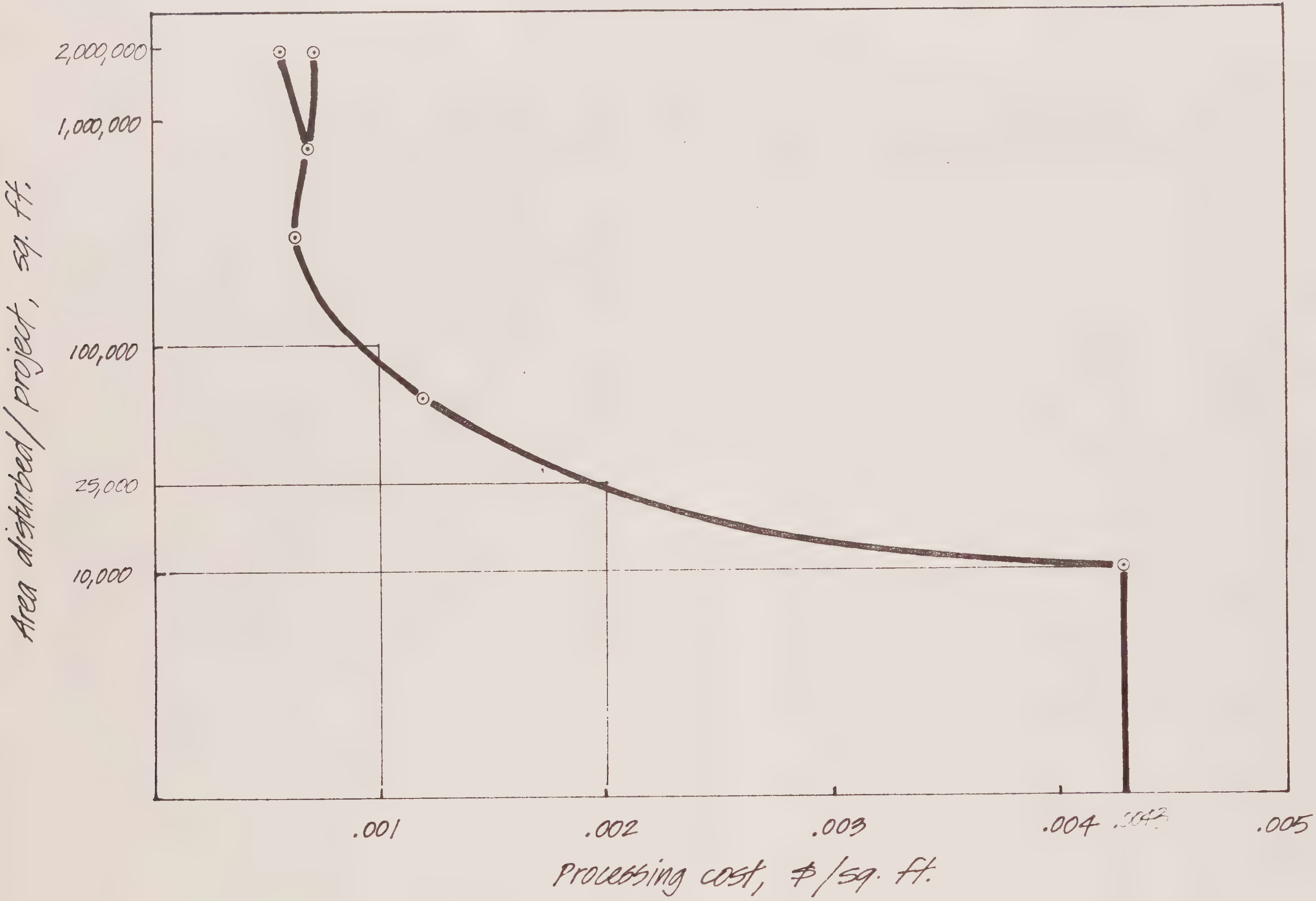


Figure 1. **Processing cost/project**

With these rates, a 200-unit project disturbing 2,000,000 square feet would pay the equivalent of $10/unit. A 10-unit project disturbing 100,000 square feet would pay the equivalent of $20/unit. The small percentage of permit fees collected beyond staff time processing cost would be used to offset travel expenses and contingency costs. Alternatively, a fee schedule could be calculated based on cubic yards of earth moved per project, similar to the Solano County example.

IV. PRIVATE SECTOR COSTS

Implementation of effective erosion and sediment control plans requires additional costs for a developer to prepare the plan and construct the control measures specified therein. Costs for construction of erosion control measures are generally lumped together with total grading costs and are often project-specific. The Montgomery County Sediment Control Section cites current costs to developers for erosion controls at $300-400/housing unit. In a comparison of the construction cost indexes* for Maryland and the Bay Area the index for April 1980 was:

$$\frac{\text{San Francisco}}{\text{Baltimore}} = \frac{3834.33}{2750.71} = 1.39$$

Thus, the Maryland costs translated for Bay Area conditions would range from $417-556.

In an attempt to obtain costs more relevant to the Bay Area, ABAG conducted a survey of local construction projects that have used erosion control measures during construction. Although local grading ordinances typically do not require erosion control plans with project grading permits, several Bay Area communities presently require that erosion control specifications be incorporated into a project grading plan where the development is one or more of the following:

1. of significant size (minor and major subdivisions);

2. situated on a site with high erosion potential;

3. tributary to a sensitive watercourse or natural area; or

4. tributary to a water body used for recreation or water supply.

To assess the economic effect of erosion and sediment control measures on new projects, ABAG interviewed city and county grading departments for the names of projects where a substantial degree of erosion and sediment control work has been performed--such as might be required under the recommended model ordinance features in Table 1. Jurisdictions surveyed included Alameda County, Contra Costa County, Santa Clara County, Solano County and the cities of Hayward, Saratoga and Fairfield.

Subsequently, the developers were interviewed and, where available, information was obtained for each project on:

- o project size, number of units and slope
- o control measures used
- o estimated costs of control measures
- o average cost of control measure per unit
- o general evaluation of control measure effectiveness and problems encountered

*ENR Market Trends, Engineering News Record. April 17, 1980. Indexes are based on 1913 U.S. Average = 100.

The survey results are presented in Table 8. The survey focussed on hillside construction because erosion control is most critical in those areas. The majority of the costs were drawn from winter 1979-80 estimates provided by the developers with a few projects beginning several years earlier.

Project Size and Slope

The projects surveyed were moderate to very large subdivisions. Projects of this magnitude generally kept a separate account of grading costs and in most cases kept track of erosion control costs. Measures employed varied greatly depending on the difficulty of the terrain and the particular measures required by a city/county grading department at the time of plan evaluation.

Several small subdivision developers (less than 40 units or less than 10 acres) were also interviewed. Generally, small projects and small-scale developers did not keep an itemized account of construction expenses--particularly for erosion control. Where possible, a general estimate was made based on the type of control measures used. Although limited data was available on this project size, the average cost per unit fell within the same range as the larger projects.

Erosion Control Measures Implemented in the Bay Area

All projects surveyed had approved grading plans developed by an engineer. The grading plans specified sediment retention structures such as sediment basins and included design specifications and calculations depending on the size of the basin. Drainage ditches and other erosion control devices such as storm drain inlet protectors, straw bales, silt fences, etc., were either indicated on the site plan or included in the written specifications. A grading schedule was usually included, but adherence to the schedule appeared to be the weakest link in the plan. Grading into the rainy season and a sharp demand for hydroseeding contractors just prior to the rainy season left several projects unprotected as the winter rains began.

Erosion and sediment control measures were separated in the analysis from general grading, slope stabilization and storm drainage construction activities. The latter activities were normally required for a grading or building permit regardless of whether an erosion control plan was prepared. The object of the analysis was to assess the incremental costs of a grading plan that would be brought about by the implementation of erosion control.

Hydroseeding and Hydromulching--The amount of slopes vegetated was generally greater in the larger projects which involved extensive grading and extensive open space areas. Costs varied from \$300/acre to \$1000/acre. The lowers cost reflected a basic grass mix while the higher cost compensated for steep areas that needed to be hydroseeded several times or included special wildflower/grass mixes for aesthetic variety. Of all the control measures employed, hydroseeding/hydromulching success was most critically tied to proper timing of application.

TABLE 8

EXAMPLE EROSION CONTROL COSTS ASSOCIATED WITH HILLSIDE RESIDENTIAL CONSTRUCTION - (IN 1979 DOLLARS)

Development / Developer	Project Location	Project Size / slope	Erosion Control Measures Implemented	Estimated Costs ($)	Approx. Cost ($ /unit)	Erosion Control Effectiveness	Comments
Briar Ridge Centex Homes [1]	Cull Canyon - above Castro Valley, Alameda County	192 units approx 80 acres 5-30 % slopes	Hydromulching 4 sediment basins 40 storm drain inlet cages Admin. + Engineering *	~26,000 6,300 12,000 600 44,900	$234** /unit	Poor in first year - failure of sediment basin; fair in second year [2]	Level of control effort and maintenance not adequate in first year contributed to sediment problems in Cull Reservoir
Highland Glen Centex Homes [1]	City of Hayward - hill above Ziley Creek Alameda County	Phase I - 350 units (total planned = 800 units) approx. 140 acres 5-30 % slopes	Hydromulching Engineered sediment basin (permanent w/ spillway + access) Admin. + Engineering *	~54,900 90,000 9,000 153,900	$440/unit	Good - adequate protection of Ziley Creek and sensitive areas [3]	
Jensen Ranch Phase I - Castro Heights Shappell Industries [4]	~~Tract 4460~~ Hayward hills, Alameda County	Phase I - 280 units (5 phases planned - 1200 units total) over 500 acres 5-30% slopes	Hydroseeding Hydromulching 18 sediment basins Basin maintenance Admin. + Engineering *	75,000 20,000 72,000 15,000 7,200 189,200	$676 /unit	Fair - minor slope failure, timing problems - grading into rainy season, late hydroseeding; effective sediment basins [3]	Costs include protection for roads and other phases - and will be partly covered by a special assessment district.
Lakeridge Estates Orlando Homes [6]	Tracts 3921 & 4204 off Kelley St. in Hayward Hills	Phases I/II - 80 units (4 phases planned, 160 units total) 5-30% slopes	Hydromulching sediment basins other	~24,000	~$300/unit	Fair - clogged drains led to overflow events (storm drains were used with sediment basins [3,5]	
Canyon Lake Pro Land Devel. Co. [7]	Hayward hills off Kelley St. Alameda Co.	72 units, 14 acres 5-30% slopes	Hydromulching 3 sediment basins Dike traps Straw bale dike other measures Admin. + engineering	9,600 3,100 9,700 6,300 7,400 5,800 41,700	$576** /unit	Good in 1978, poor in 1979 significant sediment run-off from bare yards and dirt spoils on newly paved streets [3,5]	Excess sediment into Don Pedro Reservoir - complaint made to RWQCB by E. Bay Regional Park District This project had higher erosion control costs because Alameda Co. required additional meas. for controlling runoff above site.

* Administration + Engineering fee estimated at 10% of sediment basin + other engineered measures construction cost

** 1978 Dollars

ABAG, May 1980

TABLE 8 Continued
EXAMPLE EROSION CONTROL COSTS ASSOCIATED WITH HILLSIDE RESIDENTIAL CONSTRUCTION - (IN 1979 DOLLARS)

Development / Developer	Project Location	Project size/slope	Erosion Control Measures Implemented	Estimated Costs ($)	Approx. Cost ($/unit)	Erosion Control Effectiveness	Comments
Orindawoods, Harold Smith Co.[8]	Orinda, Contra Costa County	368 units 190 acres 5-40% slopes	Hydromulching (native grass mix + wildflowers) 12 sediment basins Basin maintenance Other measures Admin. + Engineering*	86,000 72,000 8,000 5,000 7,700 178,700	$486/unit	Good - hydromulching very effective; minor slope + runoff problems contained on site[9]	Project continuous since 1972. Some areas required hydromulching several times; special grass/flower mixes were more expensive than usual.
Brian Ranch Harold Smith Co.[8]	Stone Valley - Alamo, Contra Costa County	Phase I - 108 units (3 phases planned - 328 units total) 626 acres 5-30% slopes	Hydromulching Engineered retention basin (14 acres) Other measures Admin. + Engineering*	15,000 ~ 350,000 ~ 5,000 35,500 405,500	$1236/unit	Good - adequate protection of watercourse; minor slope + runoff problems all contained on site[9]	Dual use retention/sediment basin used for flood control. Costs and control measures are unique for this project
Blackhawk[10] Blackhawk Constr. Co.	Danville, Contra Costa County	Phase II - 985 units (3 phases planned - 1275 units total) 1600 acres 5-30% slopes	Hydromulching 2 sediment basins Other measures Maintenance + basin removal Admin. + Engineering	27,000 25,000 20,000 40,000 4,200 116,200	$118/unit	Fair prior to sediment basin construction - silt runoff to creek; Good after sediment basin + drainage adjustments	Cost savings from re-use of equipment from other project. sediment basins very effective
McBail Construction Co.[11]	Crockett, off Pomona St., Contra Costa County	127 units on 46 acres, 83 acres total, 5-30% slopes	Hydroseeding 2 sediment basins Other measures including basin repair and clean-up Admin. + Engineering*	25,000 20,000 15,000 2,000 62,000	$488/unit	Poor in winter 1979 - late hydroseeding, sediment basins overloaded, significant sediment runoff beyond site to streets, adjacent yards, tennis courts and local swimming pool.[9]	Sediment problems due mainly to grading late into rainy season, late installation of control measures and ruggedness of site. Approx. $65,000 was spent for clean-up outside of site
Centex Homes[1]	Hercules, Contra Costa County	1100 units ~ 315 acres 1% slope average	Hydroseeding Other measures Admin. + Engineering*	123,200 ~ 10,000 ~ 5,000 138,200	$126/unit	Good - adequate site protection	Typical example of gently sloping site

* Administration + Engineering fee estimated at 10% of sediment basin + other engineered measures construction cost

ABAG May 1980

TABLE 8 (Continued)

REFERENCES

1. Bill Leonard, Centex Homes--San Mateo, CA. Personal Communication on April 22, 1980.

2. Rick Baker, Engineer, Alameda County Flood Control and Water Conservation District. Personal Communication on April 22-24, 1980.

3. Ron Gashew, Inspector, City of Hayward Public Works Department. Personal Communication on April 24, 1980.

4. G. McFadden, Land Development Division, Shappell Industries, San Jose, CA, Personal Communication on April 22, 1980.

5. Kern Hansen, Engineer, Alameda County Flood Control and Water Conservation District. Personal Communication on April 22-30, 1980.

6. Jim Wilburn III, Orlando Homes, Hayward, CA. Personal Communication on April 23, 1980.

7. Craig Prouty, Pro-Land Development Co., Walnut Creek, CA, Interview on May 6, 1980.

8. Don Doughdy, Harold Smith Co., Walnut Creek, CA. Personal Communication on April 28, 1980.

9. Gordon Whistler, Chief Grading Inspector, Contra Costa County Grading Department. Personal Communication on April 28-May 2, 1980.

10. Neil Stone, Blackhawk Construction Co., Danville, CA. Personal Communication on April 28, 1980.

11. Mike Gallagher, McBail Construction Co., Lafayette, CA. Personal Communication on April 29, 1980.

Sediment Basins-- The number and size of the basins depended upon the drainage patterns and type of terrain. The most common type were shallow pits intercepting drainage in swales that later became small streets or cul-de-sacs within the development. Other basins were designed as permanent structures in conjunction with storm drains and/or flood control. The Brian Ranch Project in Alamo includes a 13-14 acre retention basin to trap sediment and retard peak runoff flows into the adjacent watercourse. Calculating an average unit cost in this case is misleading as some portion (not easily determinable) is attributable to flood control. Typical costs for constructing a temporary sediment basin ran $3000-9000 and included labor, equipment rental, basin hardware, maintenance and basin removal at project completion. Where a project included many sediment basins, maintenance costs were itemized when available.

Other Measures--These included interceptor swales, ditches, silt fences, straw bale diverters, storm drain inlet protectors and other devices depending on the project. Cost estimates for these measures are often best guesses and vary from 1 to 15 percent of the erosion control measure costs. Usage of these other measures often depended upon the experience of the developer and the on-site recommendations of the field engineer as well as the grading plan specifications.

Administration and Engineering--Erosion/sediment control planning and design were typically included in the grading plan and it was difficult to break out that portion related only to erosion control. Generally, to include erosion/sediment specifications in a grading plan, required only a modest incremental effort by the project engineer(s). Administration and engineering generally comprise a minor cost compared to actual facilities construction. For the purpose of this survey, the administration and engineering fee was estimated at 10 percent of the construction cost of sediment basin(s) and other engineered measures. Typically, sediment basins were one of the most significant cost items and usually required an engineering design.

Approximate Unit Cost

Based on Table 8, the range of costs vary from about $250/unit to around $550/unit (in winter 1979 dollars) for hillside projects and less than $250/unit for flat to gentle sloping areas. Costs for erosion control work continuing through spring 1980 have been roughly in the same range. Some projects with unique conditions average a higher per unit cost but often reflect the inclusion of costs other than erosion control or costs not directly chargeable to the consumer (i.e., costs that may be split with a special county assessment district for road and utilities provision). The cost range noted above covers general hillside conditions but individual projects may incur higher costs due to the difficulty of the site.

Typical hillside developments in the Bay Area range from less than 1 to 4 units/acre. Thus, the private costs per unit would range from $250/acre to around $2,200/acre with an average estimated at $1,000/acre due to the lower density of hillside developments.

Erosion control costs on projects with gentle to relatively flat slopes were significantly less and averaged, on a per unit basis, half of the hillside control costs or less--as shown in the last example on Table 7.

Erosion Control Costs for Small Developments

The focus of the ABAG survey was mainly upon moderate to large developments because erosion control was mandatory on these projects due to the large erosion potential. The measures developed in the ABAG Manual of Standards for Surface Runoff Control Measures are most effective when applied to large grading projects. While some of the measures would be costly for smaller developments, other measures, such as straw bale dikes and diversion ditches, are adaptable to smaller projects. It is anticipated that in the 1980-81 Surface Runoff Program, specific measures will be revised, adapted and recommended for small construction projects. At that time, a more accurate assessment of erosion control costs to small projects can be made.

During the ABAG survey several small projects that utilized erosion control were reviewed. In most cases single family residences were categorically exempt. The ABAG model ordinance excludes owner-built single-family residences and land disturbances of less than 1/4 acre, unless the project occurs within 100 feet of a watercourse or sensitive natural area. Cost data was difficult to obtain as most small developers did not separate erosion control costs from grading costs or they worked only in the summer--obviating the need for erosion control devices. Small projects, especially single family residences, often had unique or very site-specific soil and terrain conditions and would best be evaluated on a case-by-case basis. Based on a limited analysis, small projects would probably incur erosion control costs on the same order as the large projects when erosion/sediment control was performed in conjunction with regular grading work. If erosion control were performed separately, then costs could be twice as much or more, than when performed with the grading work.

V. COMPARISON OF EROSION CONTROL VS. SEDIMENT CLEAN-UP COSTS

Implementation of erosion controls on a per unit or per acre basis can prevent excessive sediment deposits in local water bodies. Not only are the deposits costly to remove, but they can degrade the aquatic environment and reduce natural productivity. This section reviews:

- the range of sediment generation after construction disturbance;
- the direct costs to remove equivalent sediment volumes from surface waters and replace lost soil; and
- the indirect costs related to erosion and sedimentation, such as property and environmental damage compensation.

Construction-Related Sediment Runoff

Open space and agricultural background sediment emissions for the Bay Area have been estimated at 3.3 cubic yards/acre/year (Jackson, 1980). Uncontrolled construction can contribute 59 to 300 cubic yards/acre/year of sediment to reservoirs, streams and the Bay. With the implementation of effective erosion control measures, the increase in sediment runoff can be controlled to 1.7 - 2 times the background level. Table 8 presents some hypothetical ranges of sediment generation under several conditions.

TABLE 9

Construction-Related Sediment Emissions

Degree of Disturbance	Typical Estimated Soil Loss, cubic yards/acre/year
No construction--open space/agricultural (background rate)	3.3
Construction	
Case 1 with erosion control measures	6.6[a]
Case 2 with heavy erosion (typical for construction (without controls)	59
Case 3 with severe erosion (without controls)	300

[a] Calculated at 2 times the background rate.
Source: Jackson, 1980.

Sediment Clean-Up Costs

The Soil Conservation Service has estimated that uncontrolled sites may require 2-5 years to restabilize. Therefore, the four levels of sediment emissions were projected over a 5-year period to calculate sediment runoff in each case as shown in Figure 2. Actual conditions at specific sites will vary. Taking the case that construction occurred within one watershed and sediment was deposited within one watercourse or lake, then the clean-up cost for equivalent sediment runoff volumes could be calculated as shown in Table 10. These costs would typically be borne by a public agency such as the local flood control district or public works department. Dredging costs are representative for 1979-80.

The soil loss rates after construction were estimated to stabilize to 0.2 cubic yard/acre/year after 2-5 years. In the Bay Area, stabilized sites in urban areas have been found to have lower sediment emissions than open space/agricultural background rates (Jackson, 1980). This is because urban areas have a high percentage (30 to 60 percent) of impervious or paved areas and extensive permanent and semi-permanent planted areas holding the soil. Open space/agriculture land uses, on the other hand, can be subject to overgrazing, annual tillage and other disturbances.

Cases 2 and 3 represent heavy to severe erosion where sediment discharge is greatest in the first year and is assumed to decrease logarithmically in successive years until it reaches a stable rate at 0.2 cubic yard/acre/year. Case 3 dramatically shows the consequence of uncontrolled erosion. In this case, severe environmental damage would probably have occurred to the receiving watercourse or lake, such as the smothering or stream bottom aquatic life, fish kills, and degradation of riparian habitat. If funds for clean-up were not available or the clean-up efforts required were very extensive, then a community might choose not to remove the sediment deposits. If a reservoir were to fill-up with sediment, then the community loss could be adjudged at the replacement cost of the reservoir, or the clean-up costs for the next community downstream.

Replacement Values for Soil Losses

Topsoil is an important resource that once lost is expensive to replace. The analysis of the impacts of construction site erosion should also include an estimate of the replacement value for soil lost. Table 11 presents the calculation of replacement costs under Cases 1, 2 and 3 as well as the no construction condition. The net potential soil lost or soil to be replaced was based on the 5-year runoff rate adjusted for natural on-site soil replenishment and "urbanized" areas where soil replacement would not be necessary. The "r" factor is the percentage of the net soil to be replaced that the landowner wishes to undertake and can vary depending upon individual site conditions.

Private Industry's Erosion Control Costs

Based on the ABAG survey of erosion control costs on existing projects, as discussed in the first part of this memorandum, typical hillside

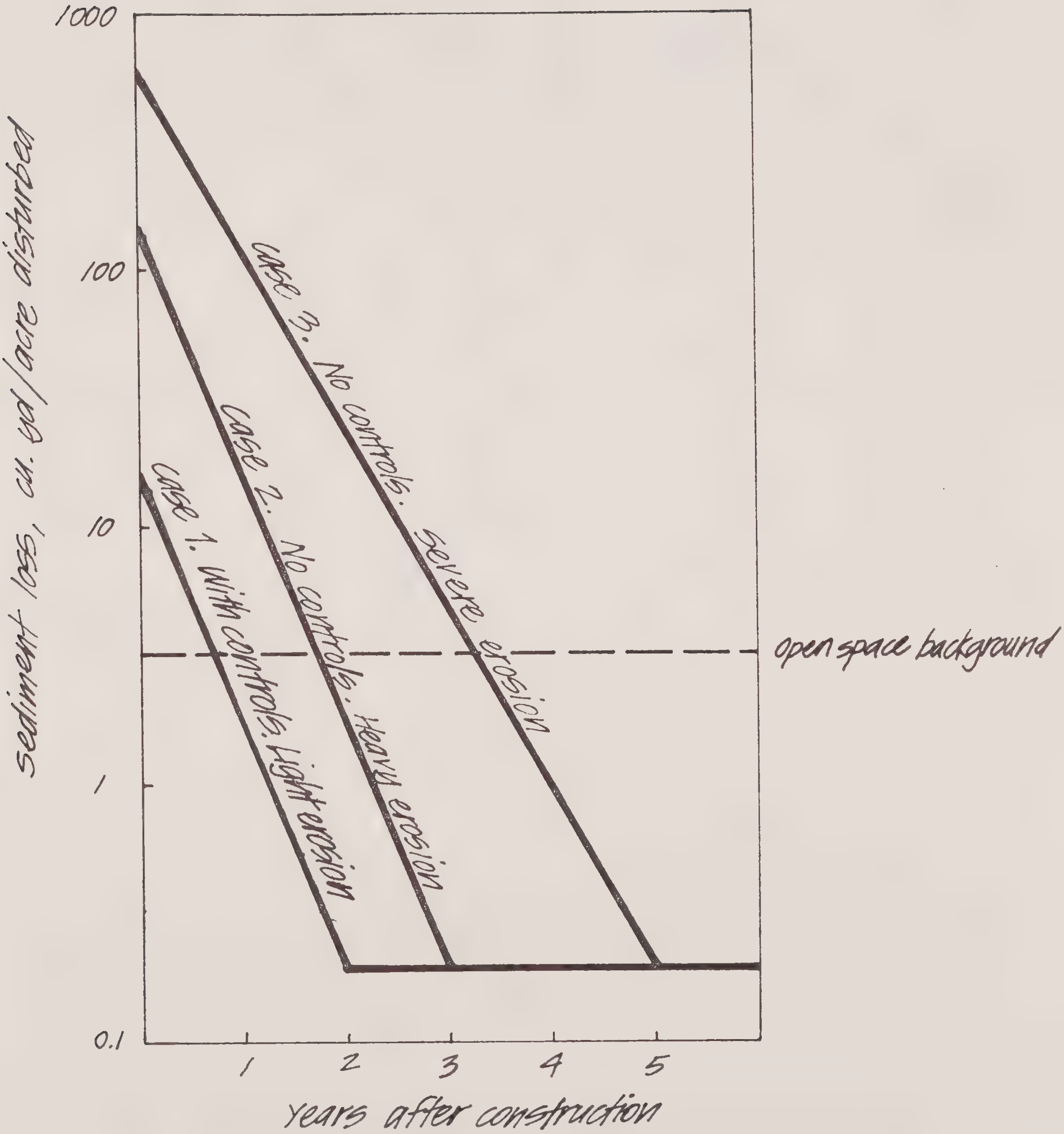


Figure 2. **Sediment loss at construction sites**

TABLE 10

SEDIMENT REMOVAL COSTS PER ACRE OF DISTURBANCE

	No Construction (open space background rate)	After Construction		
		Case 1 with controls,[a] light erosion	Case 2 no controls,[b] heavy erosion	Case 3 no controls,[c] severe erosion
Average estimated sediment runoff[d] (cu.yd/ac/yr) Time (yr)				
0-1	3.3	6.7	59.0	300.0
1-2	3.3	0.7	6.6	60.5
2-3	3.3	0.2	0.7	12.2
3-4	3.3	0.2	0.2	2.5
4-5	3.3	0.2	0.2	.5
Estimated 5-yr sediment emission (cu.yd/ac)	16.5	7.9	66.7	375.6
Sediment removal cost[e] ($/ac) (in 1980 dollars)	165	79	667	3756

[a] Site stabilization in 2 years
[b] Site stabilization in 3 years
[c] Site stabilization in 5 years
[d] Average annual discharge estimated from Figure 1
[e] Assumes sediment emissions in watershed wash down into one water body. Sediment removal would be achieved by dredging. 1980 dredging costs are approximately $10/cu.yd. (Jackson 1980).

TABLE 11

REPLACEMENT VALUES FOR SOIL LOSSES

	No Construction (open space background rate)	After Construction: Case 1 with controls, light erosion	After Construction: Case 2 no controls heavy erosion	After Construction: Case 3 no controls, severe erosion
Estimated 5-yr soil loss,[a] S_1, cu.yd/ac	16.5	7.9	66.7	375.6
5-yr. natural replenishment factor,[b] r, cu.yd/ad	not available	4.0	4.0	4.0
Urban paving factor,[c] u, paved acre/total acres	0	.5	.5	.5
On-site soil replenishment, S_r ($S_r=r(1-u)$) cu.yd/ac	not available	2.0	2.0	2.0
Net potential soil replacement S_n, $S_n=S_1(1-u)-S_r$ cu.yd/ac	not applicable	1.95	31.3	187.6
Recovery factor,[d] R, (%)	100%	100%	100%	100%
Topsoil replacement cost, T, cu.yd/ac (in 1980 $)	$8	$8	$8	$8
Replacement cost for soil eroded from site, RC, ($RC=S_n x R x T$) $/ac (in 1980 $)	not applicable	$15.6	$251	$1501

[a] From Table 9

[b] Natural soil replenishment, r, includes on-site regeneration and transport from other areas. In urban areas, little transport from outside occurs. r is estimated at 1 ton/ac=.0063 in/yr=.8 cu.yd/ac/yr (Bruner 1980). No replacement costs are associated with existing open space background conditions.

[c] Urban paving factor u is that portion of the site covered by streets, sidewalks, roofs and driveways. The coefficient for paved areas is the C factor of the Rational Method for calculating runoff. In urban areas, this is approximately 0.5 or equivalent to 50% of a site (ASCE 1969, Rantz 1971).

[d] Recovery factor R is that percentage of the soil to be replaced that the landowner desires to undertake. In all cases above, R is assumed at 100%.

erosion control costs would range from $250-550/unit. For many hillside projects, the average lot density varies from less than one to four units per acre. Thus, the equivalent per acre cost to control construction land disturbance is estimated to average $1000/acre (see Section IV Private Sector Costs). This represents a one-time cost to the developer for erosion control. In the evaluation of sediment removal costs, this amount would be added to Case 1--construction with erosion control measures.

Indirect Costs

The last factor in a comparison of costs associated with erosion and construction sites is the indirect or secondary costs associated with stormwater runoff and sediment damage.

Property damage is a very visible effect of erosion problems. Soil washed down to streets and into public and private property can damage homes, destroy landscaping and disrupt circulation when streets must be closed off. Examples of damage caused by soil and stormwater runoff are given in Appendix B. While it is not possible to determine average property damage costs, the potential liability is considerable. Some sample costs being sought by affected "downstream" communities are given below:

- Severe erosion from a construction project in Crockett, California inundated a public street, yards, tennis courts and a public swimming pool. The developer paid the equivalent of $15,000 in labor to remove sediment from streets. The County Public Works Department spent $50,000 cleaning streets and storm drains. The local school district paid to have the swimming pool cleaned and the neighborhood association banded together to clean yards and public areas.

- Soil erosion led to damage of a large retaining wall and sidewalk at a townhouse subdivision along San Pedro Creek in Walnut Creek. The homeowners association put up $1,000/unit ($93,000 total) to repair the damage. They are presently trying to reclaim the costs from the city and filing a suit for damages against the developer.

- Contra Costa County will have to set aside $1.5 million to pay for flood and storm damage to county roads and drains. Some of the major repair work done in winter 1979 included:

  - $300,000 to repair landslide damage on Arlington Boulevard in Richmond Heights

  - $200,000 to repair slide damage at Parker Avenue and Vista Del Rio in Crockett

  - $100,000 to repair slide damage along the Cummings Skyway

  - $90,000 to repair damage from three separate landslides along San Pablo Dam Road near San Pablo Reservoir

-$30,000 to level off a portion of High Gate Road in Kensington that shifted due to heavy rains

Environmental damage is another category where restoration costs and recreational/aesthetic values are difficult to quantify. Excess stormwater runoff from unprotected sites can scour watercourses, excavate deep gullies and strip an aquatic system of vegetation and major life forms. Excess sediment runoff can choke waterways, smother aquatic life and habitat and greatly diminish the value of recreational areas. Some examples are given below:

- A 22-acre townhouse project in Richmond led to severe erosion and deposition of over four feet of silt along a 3,000 foot segment of Wildcat Creek. The state Attorney General is suing the developer for $498,000, charging that the public suffered an educational and recreational loss through siltation of Wildcat Creek. This penalty could be distributed to ~$22,600/acre in the project. During the time that the problem occurred, the City of Richmond was found to have an inadequate grading ordinance or program to enforce erosion controls upon the developer.

- Increased stormwater runoff from developments throughout the Bay Area have led to the construction of riprap, retention basins and other measures to protect downstream areas. Many miles of stream habitat have been irretrievably lost not just due to storm and sediment damage, but the actual culverting, riprap, channel lining and channel reconstruction that needed to be performed to protect downstream areas.

Conclusions on Control Costs for Construction Sites

A summary of soil removal, replacement and erosion control costs is presented in Table 12. Based on the total cost associated with each acre disturbed in Table 12, the following conclusions are made:

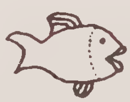
1. With an open space/agriculture land use, background sediment emissions in the Bay Area average 3.3 cubic yards/acre. It could cost about $165 per watershed acre to dredge the equivalent amount of sediment if it all ran off into one discrete water body over a 5-year period.

2. For construction in the same watershed with effective erosion controls (Case 1), sediment emissions would decrease compared to the open space background rate approximately 52 percent. The associated costs are $1095/acre disturbed, or 6.6 times greater than the no construction condition. Water quality protection would be better than average.

3. Construction without erosion controls (Case 2) leading to heavy erosion would increase sediment emissions roughly 4 times the open space background rate. The associated <u>direct</u> cost of $918/acre is 5.6 times higher than no construction and within 19 percent of Case 1. Water quality protection would be worse than average.

TABLE 12

SUMMARY OF DIRECT AND INDIRECT COSTS RELATED TO EROSION
(In 1980 Dollars)

	No Construction (open space background rate)	After Construction		
		Case 1 with controls, light erosion	Case 2 no controls, heavy erosion	Case 3 no controls, severe erosion
<u>Direct Costs</u>				
Estimated 5-yr soil loss,[a] cu.yd/ac	16.5	7.9	66.7	375.6
Cost to remove soil washed to local water body,[a] $/ac	$165	$79	$667	$3,756
Replacement cost for soil eroded from site,[b] $/ac	not applicable	$16	$251	$1,501
Private sector cost to implement erosion control,[c] $/ac	not applicable	$1,000	not applicable	not applicable
Direct costs associated with each acre disturbed	$165	$1,095	$918	$5,257
<u>Indirect costs</u>				
Property damage	$	$	$$$	$$$$$
Environmental damage to watershed and water bodies and water quality				

[a] From TABLE 9
[b] From TABLE 10
[c] See text - "Private Erosion Control Costs"

4. Construction without erosion controls (Case 3) leading to severe erosion would increase sediment emissions almost 23 times beyond the open space background rate. The direct cost of $5,257/acre is almost 32 times greater than no construction and about 5 times greater than construction with controls. Environmental damage could be severe and could last many years in this case.

5. The direct costs associated with Cases 1 and 2 for soil removal, replacement and erosion control are relatively close. However, Case 2 will also involve indirect costs for property damage and environmental degradation. While these costs are difficult to quantify on an average basis, they could raise the total costs in Case 2 several times. In the case of the Wildcat Creek damage in Richmond, the penalty that the developer may be liable for is $498,000. Distributed over the project site, this cost would be about $22,600/acre.

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APPENDIX A *

MONTGOMERY COUNTY, MARYLAND

ENFORCEMENT METHODS

SEDIMENT CONTROL ORDINANCE

I. The Program in General

A. The Sediment Control Section within the Department of Environmental Protection is charged with the responsibility to administer Chapter 19, Montgomery County Code, 1972 and Title 8, Subtitle 11, Natural Resources, Anotated Code of Maryland, 1974. These two laws make up the legal requirement for the Sediment Control Program in Montgomery County.

B. The overall goal of the section is to maintain a county-wide program to reduce soil erosion, sedimentation, and subsequent pollution and property damage to the lowest possible levels.

C. General Activities of the Section

1. Sediment Control plan review and permit processing for all urban land disturbing activities.

2. Field enforcement of sediment control requirements.

3. Investigation of complaints.

D. Budget and Workload.

1. The total operating budget of the section is approximately $180,000

2. In FY79 the section reviewed 1289 sediment control submissions, issued 911 permits, and collected $126,031 in fees.

3. In FY79 there were 11,534 inspections conducted and 1674 violations cited. There were 67 stop work orders issued, 1 bond defaulted, and no court actions.

*The following material was presented at the April 1979 Erosion-Control Seminar sponsored by ABAG and EPA. Mr. Robert Seely, Chief Field Services Section, Department of Environmental Protection, Division of Construction Codes Enforcement, Montgomery County, Maryland was the guest speaker.

II. Plan Review and Permit Processing

A. The Plan Review Unit includes two Sediment Control Plans Examiners and Clerical support to review and process sediment control plans.

B. Plans Examiner qualifications- Graduation from college with a degree in Agriculture, Civil Engineering, Soil Conservation or other related field and 3 years experience in site development and sediment control.

C. Permit application requirements.

1. Small land disturbing acitivities under 30,000 square feet do not require submittal of an engineered sediment control plan, but are approved by a Standard Sediment Control Agreement.

2. Engineered sediment control plans.

D. Bonding Requirements.

1. Small land disturbing activities permited by the Standard Sediment Control Agreement require a $400 bond.

2. Other performance bonds are required in the amount of $300 plus 2¢ per square foot of disturbed area for a maximum $10,000

3. Types of Bonds

a) Cash

b) Corporate

c) Letter of Credit

E. Permit Fee Schedule

1. $40 for small land disturbing activities

2. $.002 per square foot of disturbed area for land disturbance over 30,000 square feet.

III. Field Inspection

A. The field unit consists 5 field inspectors and a field supervisor

B. Sediment Control Inspector qualifications-Graduation from High School and 3 years of experience in erosion control, regulatory enforcement work or other applicable and responsible experience.

C. Training

1. Inspectors are given classroom training during winter months in field inspection procedures, enforcement procedures, and vegetative stabilization.

2. Field Supervisor is assigned the responsibility for providing on-the-job-training.

3. General Suggestions for effective inspection.

D. Inspection Requirements

1. General

a. 48 hour advance notice of start of land disturbance by developer

b. Initial site visit with developer and contractor to review plan, establish inspection schedule.

c. In most cases sediment control measures are to be installed prior to grading to build roads, building, etc.

d. 7 stage inspection for Sediment basins.

e. Inspections to insure construction and maintenance of major sediment control practices

f. Final inspection

2. Numbers of inspections (historical data)

a. Inspector averages about 8 inspections per working day. 200 Working days per year or about 1600 inspection yearly.

b. Each permit requires, on the average, 14 inspections per year to insure good control. This average takes in account that large projects with sediment basins require 7 inspections per basin, weekly or biweekly inspections during rough grading operations, and monthly inspections when rough grading ceases to insure measures are maintained in working order. On the other hand small land disturbing activities require as few as 2 inspections.

c. Any violation cited requires at least one follow-up inspection to insure that corrective action is taken.

d. In FY79 our inspection demand exceeded our ability to make the inspections we believed were necessary for good field compliance. As a result, priorty was given to large construction projects. Small land disturbing activities under 30,000 square feet were spot-checked and provided a final inspection.

e. Since sediment control measures are impacted by heavy rainfall, critical projects must be inspected after each storm to insure correction of problems created by storm damage.

3. Inspection Record Keeping

   a. Daily inspection summary

   b. Inspection record by permit

   c. Authorization of field modifications

   d. Certificate of final inspection

4. Enforcement procedure

   a. Notice of violation

   b. Stop work order

   c. Summons ticket to District Court

   d. Policy to obtain compliance rather than obtain fines-stop work order most efficient action

   e. Court Experience.

APPENDIX B

EXAMPLES OF ENVIRONMENTAL DAMAGE

AND INDIRECT COSTS

ASSOCIATED WITH EROSION

AND CONSTRUCTION SITES

County needs $1.5 million for flood damages

By JAMES GRAY

MARTINEZ — Contra Costa County will have to set aside almost $1.5 million in next year's budget to pay for flood and storm damage to county roads and drains.

Michael Walford, acting county director of public works, said Tuesday that floods and heavy rains this winter caused more than $3.8 million in damage to the county's road and drain system. The county had allocated about $417,000 for storm damage and slide repairs in this year's budget.

Walford said that under the terms of the state of local emergency declared Jan. 15 by county supervisors, the state is expected to provide about $1.7 million in assistance. But the federal government has twice refused to declare the county a disaster area and Walford said he expects no federal road repair funds.

Also joining in the county's application for state aid are six cities — San Pablo, Martinez, Clayton, Antioch, Lafayette and Moraga — that incurred an additional $965,000 in storm and flood damage. The state is expected to pick up about half of those expenses, Walford said.

Walford said the balance of the money will have to come from the county's general funds or from the county road fund maintained from state gasoline taxes. But he said he does not expect the supervisors to take the money from the road repair fund because it would involve cutting regular road maintenance by two-thirds and laying off one-third of the county's road crews.

County supervisors Tuesday accepted a report on the road situation from Supervisor Sunne McPeak, chairwoman of the board's finance committee.

In doing so, the supervisors approved shifts of almost $800,000 from other road maintenance projects to pay for emergency work already performed by county employees.

Walford said much of the flood repair work is in the Delta where roads were badly damaged. But he listed several projects in west Contra Costa County. They include:

- $300,000 to repair landslide damage on Arlington Blulevard in Richmond Heights.
- $200,000 to repair slide damage at Parker Avenue and Vista Del Rio in Crockett.
- $100,000 to repair slide damage along the Cummings Skyway.
- $90,000 to repair damage from three separate landslides along San Pablo Dam Road near San Pablo Reservoir.
- $50,000 to repair slide damage at Winslow and Pomona streets in Crockett.
- $30,000 to level off a portion of High Gate Road in Kensington that shifted due to heavy rains.

INDEPENDENT GAZETTE 4.9.80

The Tribune Thurs., Sept. 13, 1979 B-3

Suit asks penalties for silt in creek

Martinez—The state Attorney General has charged in a suit filed here that the public suffered an educational and recreational loss through siltation of a 3,000-foot-long section of Wildcat Creek in Richmond.

The Contra Costa County Superior Court suit blamed the siltation on grading for the 22-acre Villa Mira Vista townhouse development sandwiched between the Mira Vista Country Club and the Wildcat Canyon Regional Park.

The suit seeks civil penalties of $498,000 against the developer, the American National Development Corp. of Campbell, and three other firms with a financial interest in the development.

A penalty of $6,000 is sought against a fifth defendant, H and H Ship Service Corp., employed by American National to remove silt. The suit says H and H used hydraulic hoses to wash the creek banks, causing siltation further down the creek.

Edward R. LaCroix, attorney representing American National, said the problem has been corrected permanently. He said the company's troubles came because the city of Richmond, the park district and the Water Quality Control Board had different ideas on how to clean up the creek.

With the rainy season approaching, the company went ahead with the work, picking a contractor from a list provided by the water quality board, without waiting for agreement among the three agencies.

LaCroix said the attorney general's office found that the firm acted in good faith in cleaning up the creek.

The legal action was requested by the Regional Water Quality Control Board, which said silt deposits were as deep as four feet.

B-1

B-2

By Jim Kean

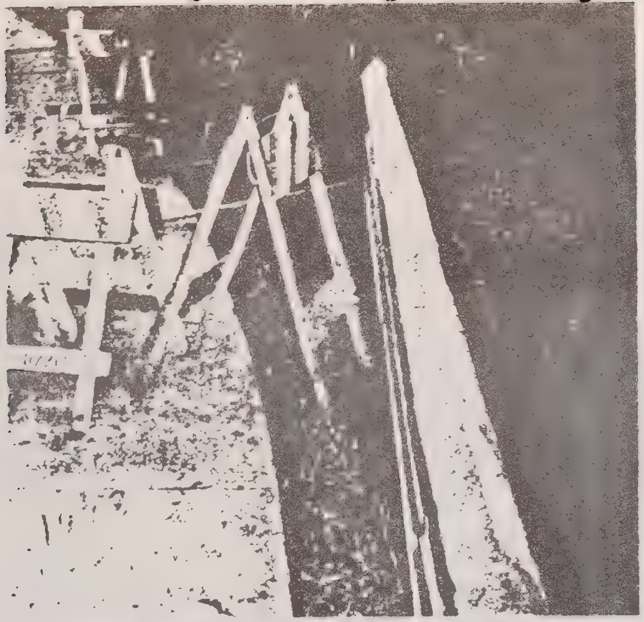
A San Rafael hillside collapsed in the storm and scattered debris for blocks on Pleasant Lane

(Times Photo)

TIMES
1.16.80

WHEN THE HILL CAME TUMBLING DOWN

Sunday afternoon, a few of the tenants at the new shopping center at Davey Glen and El Camino Real in Belmont were at work when they heard a crash. Ralph Ambler, owner of "Gifts and Stuff," said it "sounded like lightning struck." He and other tenants ran outside and saw several tons of mud from the slope just above them and below a condominium development slump over a retaining wall into their alley and under the doors of some of the businesses, most of which had just opened in the past two weeks. Shop owners who were there immediately were on the phone calling other tenants, telling them to come down and block their doors. Those who did suffer some damage were at work Monday afternoon, with the assistance of the building owner, cleaning up the mess. City Engineer Adel Nepomuceno said it appeared that the unusually heavy rain concentrated on the slope. The protective plants on the slope hadn't taken hold yet and the loose mud flowed over the wall.



Eroding Bank Is Weakening Wall, Sidewalk

Creekside Homeowners To Sue Over Erosion

Soil erosion that has weakened a retaining wall and sidewalk along San Pedro Creek in the Creekside townhouse subdivision on Rosita Road has spurred a lawsuit by homeowners there.

Bob Buyers, president of the board of directors of the Creekside Homeowners Association, confirmed that the association has hired an attorney to file suit for damages against the developer of the subdivision, Gerson Bakar Builders. Buyers declined to name the attorney, nor the amount sought.

The suit was brought on by the continuing erosion from the sidewalk side of the retaining wall which fronts the creek at the western end of the development. The erosion problem has been "a continuing thorn in the side of the association," Buyers said, but became of more immediate concern during a heavy rainstorm Christmas Eve.

During that storm, city Public Works Superintendent Frank Sampson inspected the wall and agreed that the erosion could present a safety hazard to residents using the sidewalk. Sampson provided the association with sawhorses to partially block the sidewalk to discourage further resident use.

Sampson and City Engineer Ernie Renner said the wall will have to be fixed, but acknowledged that the development is private property and the repairs will be the responsibility of the homeowners association. Neither city official could pinpoint what went wrong with the wall, although they theorized that the original footing had not been deep enough.

Buyers said association members have voted to provide up to $93,000 ($1,000 per unit) to have the wall repaired. He said the work could begin as early as next week. However, the association's contractor will have to receive a building permit first.

Renner said he thought "a good $50,000 to a $100,000" would be needed to do an adequate job.

Although the development is private property, the city may not go entirely unscathed in the resulting legal battles. The association's attorney has already submitted a claim against the city for between $90,000 and $100,000.

TRIBUNE
1·9·80

Rain takes its toll — hills road crumbles

RAIN HAS taken a heavy toll on the residents of Overlook Road in the hills above Los Gates. Only an eight foot section of the road is remaining at one point. The rest slipped into the ravine.

Photo by Amy Huntoon

TIMES-OBSERVER
1·22·80

B-3

Bob Myhre. Rains and earthquakes caused a mess along San Ramon Creek and erosion threatens his mother-in-law's property.

Erosion on San Ramon Creek Threatens Nearby Property

By TOM MARTELLA
Times Staff Writer

WALNUT CREEK — Last month's heavy rains and the following tremors shook soil loose from the banks of San Ramon Creek near Las Lomas High School here, leaving trees leaning perilously and at least one property owner wondering when she'll lose more of her land, or even her 19th-century house.

Complicating the problem is the constant erosion caused by increased water volume down the unchanneled segment of the creek, between the property of Geraldine Combs and the Creekside Glen apartments.

The creek is relatively quiet now, but future storms or tremors threaten the Combs property, she claims. She's especially concerned because the home at 1431 Creekside Dr. is the former guest house of the ranch Combs's father, Jesse Near, bought in 1910. The home was probably built about the same time as the main house, now demolished, — around 1875.

Now only the guest house, a small wellhouse and a small barn remain on the three-quarter-acre lot, itself a fraction of the former 42-acre ranch.

The creek actually divides the property, and a corner of land opposite still belongs to Combs. That segment of the creek and parts farther downstream, were purposely left "wild" five years ago as the result of outcries from the Sierra Club, Las Lomas students and local residents over plans to line the banks with concrete.

At that time, "wild" meant "beautiful" to area residents, but "it took only one winter for me to change my mind," said Combs, who owns the only single-family home in the area. She asked to have the chanelling done, but the plans died.

Now Combs sees a more urgent need for concrete channeling. Her bedroom rests 10 feet closer to the edge of the creekbank than it did before the recent earthquakes and rains. That much of the backyard tumbled down the hill, exposing the roots of the oak and buckeye trees now teetering at the edge.

But the county Flood Control District said there are no pans to block further erosion at that section of the creek, just upstream from Las Lomas. Flood control official Joe Taylor readily admitted that even more land would be lost during the next heavy water runoff.

The only solution, Taylor said, would be what Combs and her son-in-law, Bob Myhre, want — a complete overhaul, meaning concrete channeling.

"We're not mad at the flood control district," said Myhre Thursday as he walked along the bank observing the debris from fallen trees, the ragged edges of the bank, and a prominent crevice left from the January quakes.

Geraldine Combs.

But Myhre said the county should do something.

"The county certainly has responsibility because it's been approving all this development upstream," he said. "You can't increase runoff without allowing for handling it."

Runoff is increased, Myhre maintains, by developments in the San Ramon Valley area. Few dispute that.

SAN RAMON, Page 2

Storm left mark on Concord

TRANSCRIPT 12·26·79

B-5

Mud from a construction site cascaded onto Cowell Road Sunday night forcing the closure, top, of that street between North Larwin and Pembroke drives. Residents of that area surveyed the mucky scene, above Monday morning while the bulldozer in the background attempted to scrape the silt of the roadway. Below, Norman and Ralph Haman dig a trench in front of their home on Cowell Road to keep the sea of mud from making further advances onto their property.

Photos by Mike Dunn

SR/Issue Paper 3/Dec. 78
S. Goldman/V. Yucel

SURFACE RUNOFF MANAGEMENT PLAN

STRATEGY FOR THE 1979/80 WORK PROGRAM

ISSUE PAPER NO. 3
DECEMBER 12, 1978

A. INTRODUCTION

(1) Purpose

The purpose of this issue paper is to describe the:

- o Long term and short term objectives of the surface runoff program
- o Proposed 1979/80 Work Program, including strategy for addressing problems and roles of ABAG and counties
- o Past accomplishments of the program and the expected accomplishments from the 1979/80 program.

(2) Background

The Surface Runoff Management Program (SRMP) was initiated in July, 1976 as part of a two-year planning effort under Section 208 of the Federal Water Pollution Control Act Amendments of 1972. The SRMP was a portion of the Environmental Management Plan for the San Francisco Bay Area. Each of the counties in the Bay Area (except San Francisco, which already had a plan) was put under contract to prepare a Surface Runoff Management Plan for its jurisdiction. ABAG was responsible for coordinating plan preparation.

Much was accomplished during the first two years of the surface runoff program. However, to put the program in the proper perspective, one must remember that 2½ years ago (when the program began) many of the local government participants had never heard of surface runoff. Therefore, a major portion of the initial effort had to be devoted to raising the awareness of local government officials about surface runoff and training participating county staff. Before work could begin on plan development, a considerable amount of time had to be spent on defining the problems.

(3) Accomplishments

The accomplishments during the initial two years of the program are briefly summarized below:

- o eight county lead agencies selected, staffed and organized to perform surface runoff work
- o county staff trained on surface runoff issues - data collection, monitoring, modeling, problem analysis, control measures evaluation, plan formulation
- o surface runoff problems identified
- o monitoring programs conducted in eight counties in watersheds representing the major land uses in the region
- o literature reviewed and agencies surveyed in eight counties to obtain existing knowledge about problems
- o surface runoff models set up and applied in all counties to compute pollutant loads to receiving waters
- o model results compiled and analyzed
- o regional and local level advisory committees organized and administered over 2½ years
- o workshops and informational meeting conducted with local agencies and the public
- o surface runoff plans formulated in eight counties: existing control measures practices inventoried, existing ordinances inventoried, control measure recommendations formulated, management agencies designated, impacts of plan assessed, continuing planning process initiated.

Draft county surface runoff plans were completed by each of the eight counties in the fall of 1977. These plans were then reviewed and commented on by various local, regional, state and federal agencies, most notably the Regional Water Quality Control Board, the State Water Resources Control Board and the Environmental Protection Agency. In response to these comments, the counties revised and updated their plans in the form of Progress Reports (dated June 30, 1978). These eight Progress Reports were published in their entirety together with a regional summary in SRMP Progress Report No. 19, "Status of County Surface Runoff Plans," August 8, 1978.

Since that time the counties have worked on the development of work programs for 1979 and beyond. A few counties have also been pursuing demonstration project grants using non-208 funding sources. The regional Surface Runoff Advisory Committee has continued to meet during the interim as have some of the county surface runoff TAC's.

B. OBJECTIVES FOR SURFACE RUNOFF PROGRAM

(1) Long-Term Objectives

Water Pollution Control Objectives - The long-term water pollution control objectives of the surface runoff program are to:

(a) improve the water quality of the Bay Area's streams and lakes and the Bay itself to the maximum practicable extent

(b) comply with Federal and State water quality standards and objectives

(c) realize the existing and potential beneficial uses of the surface waters identified in the Water Quality Control Plan for the San Francisco Bay Basin.

Local Government Planning Objectives - The following planning objectives are proposed as a means of achieving the long-term water pollution control objectives:

(a) to raise the awareness of decision-makers and residents of the Bay Area concerning the nature, causes and control of the region's water quality problems

(b) implement procedures for continuing consideration of water quality issues in all phases of local government decision-making

(c) to have local government develop and implement policies, regulations and enforcement procedures sufficient to achieve the long-term water quality objectives.

(2) Objectives for the 1979/80 Work Program

Water Pollution Control Objectives-

(a) improve understanding of effects of control measures on water quality

(b) improve understanding of relationships between rainfall, land use and surface runoff

(c) develop control programs to improve the quality of and increase public usability of several high use urban lakes

(d) begin to reduce erosion and sedimentation problems by demonstrating the ability of local government policies and regulations to control erosion and sedimentation in key problem watersheds in the region

(e) improve the ability of city and county ordinances, regulatory procedures and control measures to reduce pollution from surface runoff, with emphasis on erosion control.

Local Government Planning Objectives

(a) improve intra-county coordination in water quality planning and implementation including:

- o county/RCD coordination
- o county/city coordination
- o county inter-departmental coordination
- o city inter-departmental coordination
- o county/special district coordination

(b) achieve a higher level of understanding about land use/surface runoff relationships among local government officials and the public

(c) integrate water quality considerations into all phases of local government decision-making

(d) improve inter-county coordination through information sharing and regionally coordinated local policy development.

C. THE PROPOSED 1979/80 WORK PROGRAM

1. Approach

The proposed 1979/80 Work Program is composed of tasks aimed at fulfilling the objectives stated in Section "B" above. This Work Program will continue the process developed during the initial planning effort. The major emphasis will be on refining and augmenting local government policies, ordinances, enforcement and control measure practices to make them consistent with the achievement of water quality objectives.

The proposed work can be divided into four major groups of tasks:

(1) regional and intra-county coordination

(2) evaluation of existing ordinances, enforcement practices and control measures regionwide and development of improvements

(3) development of detailed programs to control pollution of urban lakes and to control erosion in selected rural watersheds

(4) demonstration projects to test the effectiveness of control measures and to better quantify rainfall-land use-runoff relationships.

The last group of tasks is already underway and is funded from other sources.

(2) Proposed Activities Under Coordination Tasks

The importance of regional and intra-county program coordination cannot be overemphasized. Surface runoff is a complex region-wide problem which affects and is affected by all jurisdictions in the nine counties of the Bay Area. Table 1 summarizes the proposed activities in 1979/80 Surface Runoff Program and their relationship to past work. ABAG will continue to administer the program which involves the active participation and coordination of county lead agency staff and federal agencies. Meetings will be held on a regular basis and the group will continue to meet to discuss the continuing planning process. ABAG will provide guidance and assist local governments through:

- development of uniform standards for evaluating problems, ordinances, control measures and implementation
- dissemination of technical information and new federal and state policies and guidelines
- applying detailed knowledge gained in one specific area to similar areas
- continuing technical analysis through demonstration projects
- workshops, program guidance memoranda, issue papers and public education materials
- reviewing county programs and integrating with the existing plans.

Intra-county coordination activities to be conducted by the counties will include:

- liaison with city governments, RCD's, special districts and other county departments
- regular meetings of county advisory committees
- seeking management agreements with designated implementing agencies

TABLE 1

SUMMARY OF 1979/80 SURFACE RUNOFF WORK PROGRAM TASKS AND ACTIVITIES

Major Tasks in the 1979/80 Workplan	Relationship with 1976/78 Program Tasks	Activities in 1979/80 Workplan
Coordinate Surface Runoff Control Planning regionwide and provide technical assistance to counties.	The structure for regionwide coordination was set up during the first two years. It included the following two committees: o a working committee composed of county lead agency staffs. o a regionwide advisory committee composed of members of regional, state, and federal agencies and representatives of special interest groups. The committees had functioned very well in the past two years. Therefore, ABAG will continue the regional coordination through the established committees and will provide necessary guidance and technical assistance to the counties in conducting the surface runoff program.	Development of uniform standards for evaluating problems, ordinances, control measures and implementation. Dissemination of technical information and new federal and state policies and guidelines. Applying detailed knowledge gained in one specific area to similar areas. Continuing technical analysis through demonstration projects. Workshops, program guidance memoranda, issue papers and public education materials. Reviewing county program, and integrating with the existing plans.
Coordinate surface runoff planning within each participating county.	The county lead agencies had coordinated the surface runoff planning activities within the counties in the past. Coordination activities included: o Formation and meetings of county surface runoff advisory committees. o Meetings between county lead agency staff and other local agencies throughout counties. o Presentations before city councils and other public meetings. o County citizen round table discussions. o Development of informational brochures and slide shows on surface runoff. Similar activities will be performed by the county lead agencies in 1979.	Liaison with city governments, RCD's special districts and other county departments. Regular meetings of county advisory committees. Seeking management agreements with designated implementing agencies. Developing work programs for continuing planning and funding sources for plan implementation.

TABLE 1 (continued)

Major Tasks in the 1979/80 Workplan	Relationship with 1976/78 Program Tasks	Activities in 1979/80 Workplan
Evaluate existing ordinances and enforcement practices affecting surface runoff and develop improvements.	In the past two years, the counties had identified certain surface runoff problems and had completed an inventory of existing city and county ordinances which could affect surface runoff controls. Based on this previous work, the effectiveness and enforcement practices of existing ordinances will be evaluated and improvements will be proposed.	Detailed analysis of both ordinaces and enforcement practices regionwide. Identification of key features of ordinances with greatest potential to effect surface runoff quality and quantity. Model ordinances and model enforcement practices and improvement to existing ones to increase effectiveness in water quality management. Adoption of these ordinances and commitments to implement.
Review and evaluate existing control measures which affect surface runoff and develop programs to increase their effectiveness.	The initial surface runoff program included a preliminary survey of existing city and county control measures practices. The counties also completed a screening of a list of potential control measures prepared by ABAG. The 1979 task will be based on the results of the preliminary survey. Existing potential control measures will be analyzed and programs will be developed to increase the effectiveness of control measures.	Detailed examination of selected control measures (both in practice and potential). On-site evaluation of control measure performance Quantification of extent of application of existing practices region-wide (e.g., number of curb miles swept, type of equipment used, frequency of sweeping and litter pick-up, cost for existing programs). Recommendations for specific modifications to existing practices to increase their effectiveness - including estimation of expected effect on water quality. Quantification of cost of making above modifications Evaluations of institutional factors affecting implementation of changes. Assessment of other impacts (environment, social). Seeking of implementation of recommended improvements. Close communication between project staff and affected agencies and property owners.

TABLE 1 (continued)

Major Tasks in the 1979/80 Workplan	Relationship with 1976/78 Program Tasks	Activities in 1979/80 Workplan
Develop detailed programs to control pollution of urban lakes and to control erosion in selected rural watersheds.	Problem identification phase of initial plan development identified Lake Merritt, Lake Temescal, Cull Canyon, Nicasio Valley, Pescadero, Denniston and Calabazas Creek watersheds as priority problem areas where further work is required.	Urban Lakes: Determination of the sources of the pollution in the lakes and their relative magnitude. Development of detailed alternative measures to control the problems. Assessment of the costs, impacts and effectiveness of the alternative measures. Seeking of commitments to implement the recommended measures. Coordination of the control program with the rest of the surface runoff program. Consideration of the applicability of the control program to other areas in the region. Rural Watersheds: Determination of the source areas of erosion and their relative magnitude. Identification of existing policies, ordinances, and administrative procedures which relate to erosion control in the study areas. Assessment of the effectiveness of these measures in controlling the problem. Recommendations to improve the existing regulations and practices where indicated Procedures to control problems not currently dealt with. Consideration of the applicability of the watershed control program to other areas in the region Seeking of commitments to implement the recommendations.

- o developing work programs for continuing planning and funding sources for plan implementation

(3) Proposed Activities Under Ordinance and Control Measure Evaluation and Improvement Tasks

Nearly all local governments in the bay area have ordinances and perform control measures which affect or could affect surface runoff. Many of these ordinances and control practices were not designed to control water pollution. In addition, certain water quality problems are not addressed by existing policies, regulations or practices.

The second group of tasks is designed to build on the inventory work completed during the initial planning process (see Table 1). Key ordinances and control measures in all jurisdictions in the region which affect surface runoff will be analyzed. Modifications to improve their effectiveness for water pollution control will be developed where indicated. New policies, ordinances or control measures will be proposed to address those water quality concerns not covered by existing regulations or practices.

The overall effort in this task will be directed toward identifying and implementing least-cost best management practices to control surface runoff pollution. Evaluation of the existing ordinances and control practices will depend upon a detailed knowledge of the problems and potential control alternatives.

(4) Proposed Activities Under Urban Lakes Clean-Up and Rural Watershed Erosion Control Tasks

This third group of tasks focuses on two major surface runoff issues in the bay area: polluted urban lakes and erosion from developing and rural watersheds. Urban lakes and recreational lagoons are some of the most heavily used water bodies in the region. Continued usage of many of these lakes is threatened by pollution caused by surface runoff. This work program has identified three such urban lakes for detailed analysis and development of specific pollution control programs: Lake Merritt, Lake Temescal and the San Mateo Lagoon. Activities in the urban lakes tasks will generally include the following:

- o determination of the sources of the pollution in the lakes and their relative magnitude
- o development of detailed alternative measures to control the problems
- o assessment of the costs, impacts and effectiveness of the alternative measures
- o seeking of commitments to implement the recommended measures

- o coordination of the control program with the rest of the surface runoff program

- o consideration of the applicability of the control program to other areas in the region

Erosion and siltation is a widespread surface runoff problem that occurs throughout the region, primarily in rural areas and in areas where new construction has occurred. Erosion was reported as a problem in all eight county surface runoff plans. Several counties have selected watersheds with previously identified erosion problems for detailed analysis and development of specific control problems. Activities undertaken in these case studies will typically include:

- o determination of the source areas of erosion and their relative magnitude

- o identification of existing policies, ordinances, and administrative procedures which relate to erosion control in the study areas

- o assessment of the effectiveness of these measures in controlling the problem

- o recommendations tc improve the existing regulations and practices where indicated

- o procedures to control problems not currently dealt with

- o consideration of the applicability of the watershed control program to other areas in the region

- o seeking of commitments to implement the recommendations

The case study approach outlined for this third task group is expected to yield the following results:

- o completion of an entire cycle of detailed planning from problem identification to implementation

- o development of detailed information about costs and effectiveness of control measures which will facilitate applications to other areas

- o commitments to implement certain recommendations and identification of barriers to implementation of others

- o specific requirements for further study which will enable broader implementation of effective surface runoff control programs

(5) Demonstration Project Activities

The following demonstration projects are now underway:

- evaluation of the effectiveness of street sweeping on the quality of receiving waters in the Castro Valley Creek watershed

- assessment of the effectiveness of a marsh/flood basin in treating surface runoff

- refinement of the MAC model as a planning tool for estimating regional surface runoff pollution loads.

These projects are being supported by other EPA grants and local matching funds.

WQ Issue Paper 4/Sept.79
S. Goldman

WATER QUALITY MANAGEMENT PROGRAM

STRATEGY FOR 1980 PLAN UPDATE

Issue Paper No. 4
September 10, 1979

A. INTRODUCTION

In the initial development of the county surface runoff plans, a number of fundamental issues were raised--problem definition, effectiveness of best management practices, overall contribution of surface runoff to total water quality problems and level of control warranted given high level of uncertainty in data and analysis. The above issues posed an interesting dilemma to the region. Local governments were reluctant to carry out substantive control efforts without additional analysis that such actions would be technically effective, cost-effective, specific to local problems, and equitable. On the other hand, Federal, State and regional regulatory agencies felt the circumstantial evidence implicating surface runoff as a significant source of pollution required some actions to deal with the problem.

Posed somewhat differently, the above issues can be restated simply as follows. The Federal, State and regional regulatory agencies are concerned about the current level of implementing actions to carry out the county surface runoff plans. Specifically, they are concerned with the lack of substantial progress and meaningful commitment to effectively reduce the surface runoff contribution to water quality problems. Local governments, however, continue to develop technical information (e.g., standards and criteria) to serve as the basis of future controls which the cities and counties would implement. The purpose of this brief issue paper is to discuss the issues cited and to outline an approach to resolving these issues in the 1980 surface runoff plan update.

B. BACKGROUND

The initial county surface runoff plans have been recognized by EPA, the State Water Resources Control Board (SWRCB), and the Regional Water Quality Control Board (RWQCB) as a "first step" towards controlling surface runoff problems. Recent actions by the Regional Board suggest that local governments will need to develop and carry out their surface runoff plans further if they intend to maintain control over plan development and implementation. The Villa Mira

Vista development case in Richmond has caused the RWQCB to become concerned about the lack of adequate erosion control requirements in that city and other jurisdictions. A draft resolution now pending before the Board finds that the City of Richmond contributed to the waste discharge problems of the residential development due to its lack of erosion control policies and procedures. The resolved clause of this tentative resolution requests Richmond "to develop, implement and enforce an Erosion Control Ordinance" and to submit the ordinance to the Regional Board for review within 120 days. The Board has also referred the matter to the Attorney General for prosecution of the developer.

These actions by the Regional Board illustrate quite clearly the potential consequences for cities and counties which have not adopted or enforced adequate erosion and sediment controls. Where the Regional Board has identified problems and witnessed no corrective actions to deal with the problem, they fully intend to step in, implement and, if necessary, enforce corrective measures needed to alleviate the problem. It would appear to be in the interests of the participating counties to use the 1979-80 Work Program as an opportunity to improve local surface runoff plans and regulations and thus avoid being forced to hastily adopt new ordinances or accept regulations promulgated by an outside agency. Once this happens, local governments will have lost control over the extent, timing, and nature of control measures to deal with their unique local problems.

EPA has also expressed concern about implementation of the county plans. Their policy on continuing funding to designated agencies requires that grantees must be implementing a significant portion of their plans. The lack of technical standards and criteria in the county plans and existing local regulations is making it difficult for local governments to implement these plans.

C. ALTERNATIVE APPROACHES

There appear to be two alternatives available to local governments in dealing with the surface runoff problems. First, local governments can continue in the current mode of operation--monitoring and data collection for problem identification, selected pilot and/or demonstration projects, investigating possible ordinances--without substantive commitments to implement plans and policy actions on a fixed time schedule. Under this scenario, the likelihood of outside intervention by other regulatory bodies is high, as witnessed by the current City of Richmond situation. Alternatively, local governments can begin adopting and implementing a series of prudent surface runoff control measures which constitute sound management practices and minimal costs to local governments. As part of this second approach, it is proposed that cities and counties adopt a guide or handbook of best management practices as an official policy document. A model guide or handbook would be prepared by ABAG staff based upon this information collected by ABAG and the counties in this year's program.

This guide would contain state-of-the-art information and data on a variety of best management practices. Each city and county would select from the handbook those best management practices which would be appropriate to their own area. Thus, each area would maintain control over the ordinances to be carried out in their own area.

This guide or handbook would serve the following functions:

(1) Establish policies regarding control of water quality impacts from land development.

(2) Set forth standards and criteria for construction, operation and maintenance of erosion and sediment control measures in developing areas.

(3) Specify cost-effective procedures for street sweeping, catch basin cleaning and other common public works practices.

(4) Establish standards and criteria for best management practices on rural lands.

D. SUMMARY

The proposed local handbooks, when adopted by the cities and counties of the Bay Area, would have several major benefits:

(1) Local and regional strategy for Bay Area

The handbooks will constitute a compiled set of widely accepted best practices for dealing with site-specific local problems by local governments and developers.

(2) Regional consistency but local control

By starting from a model guide or handbook, some degree of regional consistency is assured. Yet local governments would address their own problems. Standards for similar topography and land use in one part of the region will not be radically different in another part of the region. Inequalities in land use regulations can thus be avoided.

(3) Maintenance of local control

By preparing the handbook themselves, local governments will have control over what goes into it. The influence of outside agencies can thus be minimized.

(4) Flexibility

Standards for a variety of alternative control methods will be established. Cities and counties will thus be able to choose among various practices to suit the particular characteristics of each jurisdiction.

(5) Improved water quality, lower maintenance costs

Widescale implementation of best management practices will result in reduced quantities of sediment and other pollutants to Bay Area lakes and streams. These smaller pollutant loads will also be cheaper to remove through such practices as dredging, channel cleaning and street sweeping, thus reducing public works budgets.

The issues and alternative approaches are clear. The destiny and control of surface runoff problems rests largely with the responsiveness of local governments to the challenges before them. If they accept the challenges and responsibilities, the solutions to the problem will be theirs. If local governments fail to respond to the continuing problems of surface runoff, the solutions will be mandated for them.

WQ Issue Paper 31/December 1979
Terry Bursztynsky

WATER QUALITY MANAGEMENT PROGRAM

IMPLEMENTATION OF SURFACE RUNOFF CONTROL MEASURES

Issue Paper No. 5
December 31, 1979

This issue paper addresses an important question: What regional policy should be adopted for minimum performance in the control of surface runoff pollution? This paper is written to stimulate public discussion and obtain guidance for ABAG staff and elected officials. No policy has as yet been established on this issue; however, on the basis of reaction to this paper, a policy will be recommended for the Environmental Management Plan (EMP).

During the development of the EMP, numerous water quality problems related to surface runoff were uncovered. Counties participating in the program surveyed their respective lakes and streams, and produced reports enumerating problem areas. Streams, lakes and reservoirs of the region suffered high bacterial levels, high nuisance algae growth, fish kills, smothering sedimentation, and nuisance accumulations of trash and floating debris. Although harder to discern, water quality problems in the Bay also result from surface runoff. Known problems include bacterial contamination of beaches and shellfish. Additionally, approximately half of the toxic metals reaching the Bay come in surface runoff from the region's urban areas. The impacts of these metals, and other toxic substances, are only now coming to light. The consensus of water pollution researchers is that bacterial pollution, sediment deposition and algal growth are the most serious current problems and toxic metal poisoning will be in the near future. Technical Memorandum No. 42 combines and restates water quality problems uncovered in previous EMP investigations.

Constituents of surface runoff that cause water quality problems are: soil from eroded land; nutrients such as nitrogen and phosphorus from agricultural areas and urban lawns; toxic chemicals such as pesticides, herbicides, metals and industrial compounds; greases and automotive oils; and, bacteria and possible viruses. The contribution of urban surface runoff to water pollution relative to other sources is presented in Table 1.

TABLE 1. ANNUAL FRESH WATER AND POLLUTANTS ENTERING THE BAY

Constituent \ Source	Municipal	Industrial	Total Point Source	Street Surface	Open Area	Other	Total Surface Runoff	Delta	Areal Fallout	Total Bay Input
Q*	192	19	211	43	293	44	380	4960	-200	5351
BOD_5**	115	7	122	7	7	8.5	22.5	52	5	201.5
TSS**	80	20	100	59	921	60	1040	4350	175	5665
TN**	48.5	1.5	50	1	2	2	5	28	2	85
TP**	23.4	0.1	23.5	0.1	0.2	0.2	0.5	5	0	29
Heavy Metals***	0.8	2	0.8	1.3	1.5	1	3.8	6.5	0.5	11.6

* Q, flow in billions of gallons per year.
Other constituents are in millions of pounds per year.

** BOD_5 = 5-day BOD, TSS = Total Suspended Solids, TN = Total Nitrogen, TP = Total Phosphorus

*** Total equivalent heavy metals expressed as chronic toxicity equivalent of chromium.

Note: Point source figures show 1978 level of treatment

Surface Runoff Control Measures

Surface runoff control measures may be grouped in four categories: those that reduce the volume of stormwater runoff by containing it at the site; those that prevent pollutants from entering the runoff; measures, or treatment processes, that remove pollutants from stormwater; and instream measures that offset the negative impacts of stormwater pollution. Preliminary analyses of costs and benefits, conducted for the EMP, resulted in the conclusion that non-structural best management practices should be emphasized. This would tend to eliminate the costlier treatment systems. Instream modifications or measures have not been explored to any great extent and would require a modest research effort before they could be considered practical in the Bay Area. An exception to this is the use of natural marshes for removing pollutants from runoff. This technique, now the subject of a demonstration project being conducted by ABAG with the cooperation of the Santa Clara Valley Water District and City of Palo Alto, shows very promising results.

Thus, the control measures receiving the greatest attention are directed at reducing runoff quantities or pollutant content as preventive measures. The following surface runoff control measures are being developed and refined by ABAG and participating counties:

- Construction erosion controls
  - Ordinances
  - Erosion control plans
  - Enforcement practices
  - Interim structural practices
    - Sedimentation basins
    - Sediment traps
    - Diversion dikes
    - Interceptor dikes
    - Perimeter dikes
    - Perimeter swales
    - Outlet structures
    - Construction entrance
    - Grade stabilization
  - Permanent structural practices
    - Diversions
    - Grassed waterways
    - Impervious waterways
    - Riprap
    - Storm drain outlets
    - Sedimentation basins
  - Vegetative practices
    - Temporary cover
    - Permanent cover
- Public works practices
  - Control of chemicals
  - Street sweeping
  - Litter control
  - Storm drain system maintenance
  - Street surface and repair
  - Leaf removal
  - Domestic animal wastes

Agricultural Practices
- Land management for erosion control (e.g., contour farming, livestock rotation, water spreading and fencing)
- Fertilizer, herbicide and pesticide application
- Animal and agricultural waste management
- Farm ponds
- Grading for rural construction on farm roads

Issues

The major issue we are trying to resolve is what degree of implementation is appropriate for the Bay Area and what commitment we are willing to provide. This question arises as a result of several problems or difficulties which are discussed below.

Uneven Implementation

Although surface runoff pollution occurs in every county (and we are not discussing the exceptional case of San Francisco) the degree of concern or control measure implementation is very uneven. It could be argued that such unevenness is a response to varying local conditions as best determined by local governments. However, when the responses approach zero, one can question the appropriateness of such actions. Communities which select the easiest course might be ignoring their surface runoff problems and certainly run a risk of intervention by State agencies.

Applicability of Controls

All controls are not applicable for all areas. Highly urbanized areas require different levels of public works services than low density suburbs. Rapidly growing communities have greater needs for erosion control practices than do older, established neighborhoods. Agricultural areas have significantly different problems than urban areas.

These differences point out a problem of trying to control surface runoff pollution by the establishment of a uniform level of technology. Certain communities could be burdened with an unnecessary level of control and expenditure while others may fall short of their control needs.

Indeterminate Benefits

The various control measures fall into two categories: those that provide complete control; and those that provide control with an indeterminate level of benefit. An example of a complete level of control would be a stormwater retention pond designed with the objective of reducing runoff quantities. An indeterminate measure could be street sweeping or vegetative practices. Unlike wastewater treatment facilities, where a given expenditure will achieve a given pollutant reduction, most surface runoff control measures produce benefits that are less well defined. A major reason for this is that, under highly varying local conditions, there is a significant shortage of performance data. As a result, we

must often mathematically model expected benefits using national or regional data. It is difficult to fault local governments for not committing to an expenditure when the performance or benefits are not precisely defined.

Another aspect of benefits relates to receiving waters. Biologists and hydrologists can qualitatively declare the improvements to be obtained when some pollutant is reduced or removed. But, because of our imperfect understanding of biological systems, it is extremely difficult to state what precise changes would occur, in what quantity, how significant they would be to a system, or even if the alternative biological scenario would be unacceptable just because it may be different. Only in extreme cases, where we may have stream dredging, or fish kills, or contamination of a water supply can we readily produce a benefit of control measures. Thus, when asked "What difference will it make" or "Prove the need for this measure," an extremely large effort must be expended to provide conclusive information on a case-by-case basis.

Local Government Costs

Any control measure will involve some expenditure. Controls such as public works practices are financed entirely by local government. Fortunately, most of these originated for other purposes such as aesthetics or public safety, and their cost does not have to be justified by water quality benefits alone. However, after the passage of Proposition 13 we find cities cutting back on services in order to meet their budget limitations. Under such circumstances, to what degree should water quality needs compete for funds with other local government services?

Private costs

Some surface runoff controls would mandate additional costs upon private individuals or companies. A typical example might be the need to construct sediment catchment basins during land grading for factories or housing developments. This could be a very legitimate requirement because erosion from disturbed soil is from 20 to 2000 times greater than from undisturbed soil. Yet with current house permit, inspection, and EIR costs reaching $2000-3000, can local government successfully withstand challenges against additional requirements?

Alternatives

There are three basic alternatives which could be adopted as a policy into the EMP.

The first alternative would be to adopt all control measures in a program to prevent, by any means possible, all surface runoff pollution. It is

likely that this would be overkill in most communities and could not be financially justified with other city budget items.

At the opposite extreme, no control measures for surface runoff would be instituted until a water quality problem had been documented and an appropriate degree of control determined. This approach would certainly minimize expenditures for local governments, however, substantial and possibly irreversible damage may occur as a result of inaction. The question to be asked with this alternative is whether we must first kill fish, smother stream beds, foul our waters with massive algae blooms or contaminate beaches before corrective action is taken.

A final alternative is not as well defined but is favored by ABAG staff. Local governments would adopt some mix of control measures to prevent obvious or high risk sources of pollution. Other control measures would be reserved for corrective action in cases of documented pollution.

It is suggested that ordinances for grading and watercourse protection be adopted by all cities and counties. Concurrently, control measures for erosion reduction would be implemented at construction sites and agricultural areas. Public works practices that provide multiple benefits, such as storm drain cleaning or street sweeping, would be altered to increase water quality benefits, possibly with no increase in expenditures. Other measures would be applied as needed in problem areas.

WQ Issue Paper No. 6
S. Goldman

WATER QUALITY MANAGEMENT PLAN

INCENTIVES FOR IMPLEMENTATION OF WATERSHED PROTECTION PLANS

Issue Paper No. 6
February 19, 1980

A. INTRODUCTION

The 1979-80 Work Program contains five major watershed case studies:

Task 22 - Develop erosion control plan for Cull Canyon
Task 23 - Develop water quality protection plan for Nicasio Valley
Task 24 - Develop erosion control plan for Pescadero Creek Watershed
Task 25 - Develop pollution control plan for San Mateo Lagoon
Task 27 - Develop erosion control plan for Calabazas Creek Watershed

These five tasks constitute about 60 percent of the total county budgets for this year's "208" program. These case studies are intended to yield implementable plans for the affected watersheds and to serve as a model to apply to other areas.

The purpose of this Issue Paper is to explore alternative ways to provide incentives or impetus for implementation of watershed protection plans. These alternatives and plans deal with watersheds in private ownership and which are undergoing soil erosion with resulting stream pollution and sedimentation. The special case of major developments occurring in a watershed is not included. Because such developments usually entail a change in ownership and land use, various control measures can be effectively applied. This paper deals with the more difficult problem of addressing surface runoff pollution from rural lands that may have been managed in a certain way for generations.

Why the present system does not work

There are several problems with the current system of land use, land use regulation and voluntary assistance programs:

1) Water quality problems caused by upstream land owners are felt by downstream owners. Thus most land users do not feel the effects of their own poor practices.
2) The costs of correcting problems in a water body are usually spread throughout an entire city, county or special district. These political units frequently cover hundreds of square miles and include dozens of watersheds. Thus, there is little incentive for the individual land owner to minimize his contribution to the pollution of the water bodies.

3) Many of the impacts caused by poor land use practices are not clearly identifiable for many years. The steady erosion of topsoil and deposition on streams, lakes and estuaries produces insidious changes in the environment which are difficult to quantify. How can one quantify now the cost of the loss of long term productivity of the land or the destruction of fish spawning grounds and benthic habitat? The subtle changes happening now will probably not become obvious for decades. By then the changes will be irreversible.
4) Land owners can accrue higher short term profits from more intense use of land. For example, Rancher A finds that he is able to graze 1,000 head of cattle on his land each year. He has been doing this for 10-15 years and has not observed a loss of productivity. The grazing of 1,000 head, however, is causing compaction of the soil and is producing some bare spots here and there. The effect is greater runoff from Rancher A's land and consequently greater flow in the creek which drains it. The resulting streambank erosion and sedimentation are felt far from Rancher A's property. Rancher A will probably not experience a noticeable drop in the productivity of his land (due to erosion of top soil) for many more years.
5) Federal cost-sharing programs do not allow federal monies to be used to fund projects that will return a profit to the land owner. When a rancher enters into a cost-sharing program, he is probably solving a long-term problem, such as an ever-widening gully. He is, however, losing money in the short term, because halting the expansion of the gully is not going to increase the short term rate of return from his ranch.

   Rancher A, for example, grazes his 1,000 head of cattle on the eastern half of his property because there is no water on the western half. If he developed a spring and pond on the west side he would be able to graze his cattle over his entire land holding. He might also be able to graze 1500 head instead of 1,000. The net effect would be less intense use of the land and probably less damage to the environment. However, because the development of the spring would return a profit to Rancher A (500 extra head), federal cost sharing would not be permitted. If Rancher A does not have the ability or inclination to fund the project on his own, the benefit to the public (better water quality) will also be lost.

The above five points illustrate why the current system tends to create water quality problems, but not the ability to solve them. The following disucssion explores four possible approaches to watershed planning, with emphasis on incentives for implementation. The advantages and disadvantages of each approach are also outlined.

ALTERNATIVE 1: Voluntary Plan

<u>Example</u>

Property owners would be encouraged to work with SCS to prepare a conservation plan of BMPs for their landholding. Property owners would be given maps of their property. Maps would divide property into subareas and list recommended BMPs for each land use in each subarea. A descrip-

tion of each BMP would also be provided. There would be no penalty for either 1) not having a conservation plan, or 2) not implementing one.

Advantages:

Politically acceptable, low initial cost to implement, no enforcement necessary, can be partially funded by federal cost sharing programs.

Disadvantages:

Widescale implementation difficult, requires public education and outreach, may require increase in federal services (more SCS personnel to develop conservation plans), little incentive for voluntary compliance (farmers may suffer high initial cost or suffer some loss in income by implementing the conservation plan for their property), easy to do nothing and have plan be ineffective.

Discussion

This alternative is probably the easiest for local government and property owners to accept, since it does not require anyone to do anything. However, regional, state and federal regulatory agencies will probably not look favorably on a purely voluntary program because a high compliance cannot be anticipated.

Possibly the strongest incentive for making this voluntary planning approach work is the availability of federal cost-sharing funds and free technical assistance from the Agricultural Stabilization Service and the Soil Conservation Service, respectively. The amount of funding available and the federal share percentage depend on the severity of the problem, the cost of the control measure, the ability of the land owner to pay and the degree of public and private benefit resulting from the project. Under present regulations, federal cost sharing is not allowed if the control measures will create profit for the land owner.

One way to increase the incentive for voluntary conservation is to allow federal cost sharing for BMPs that produce a private profit if the control measures also produce a significant public benefit. Another possibility is to supplement the federal cost-share dollars with local funds. Savings from reduced dredging and stream maintenance costs could partially fund such a local government cost sharing program.

ALTERNATIVE 2: Special District Plan

Example

A special district would be created coterminous with the watershed boundary. A tax would be assessed on property owners in the watershed to cover the costs of dredging and channel maintenance. Assessment would be based on the estimated sediment discharge rate from each property (e.g., acres x slope factor x soil factor x control measures factor). The assessment rate would decrease as a function of voluntary implementation of BMPs.

The following example illustrates such an approach:

No control measures = Basic assessment rate
Level I control measures = 50% of basic rate
Level II control measures = No assessment

If little dredging and channel maintenance is done, the taxes collected could be used to finance BMPs on the property of the cooperating landowners (or a combination of both maintenance and BMPs).

Enforcement - Each property owner would file a statement with his tax bill stating what BMPs he had used that year. He would submit his tax payment much like state and federal income taxes are filed. The enforcement agency, working with the local SCS office, would spot check a percentage of the returns.

Advantages:

Costs of maintaining water quality born by those who degrade it; provides strong incentive for voluntary control measures.

Disadvantages:

Difficult to implement (requires 2/3s vote of property owners in the watershed), creates additional level of government.

Discussion

This alternative is probably not possible to achieve unless:

1) There is a strong threat of regulatory control (which appears to be the greater of two evils);
2) The water quality problems in the watershed are very serious and there is strong personal concern among the residents to preserve the quality of the area.

ALTERNATIVE 3: Local Regulatory Plan

Example

A county would pass a "Land Disturbance Ordinance" to regulate all major land disturbing activities for the purpose of protecting water quality. Regulated activities would include:

Rural and urban grading
Certain agricultural practices (such as tillage of slopes greater than 15%)
Logging practices

Performance of any of these activities would require a permit. Failure to comply with specified BMPs could result in stiff fine and/or stop-work order.

Advantages:

Puts "teeth" into plan (fear of inspector, threat of penalty), permit fees could fund administrative costs.

Disadvantages:

Imposes bureaucratic "red-tape" on use of private property, requires administrative and enforcement staff, could be costly and cumbersome to implement.

Discussion

Before this alternative could be adopted, the need for using the police power would have to be clearly established. The problems must be obvious and there must be reasonable evidence to show that implementation of the regulations (i.e., use of BMPs) would adequately mitigate the problems.

The threat of local government adoption of this alternative might provide an incentive for implementation of alternatives 1 or 2.

ALTERNATIVE 4: RWQCB Regulatory Program

Example

The Regional Water Quality Control Board could require property owners to obtain discharge permits to conduct the activities listed in Alternative 3. Failure to comply could result in prosecution.

Advantages:

Removes water quality protection from the vagaries of local politics, puts "teeth" into regulatory program.

Disadvantages:

Loss of local control over land use, imposes bureaucratic "red-tape" on use of private property, could be costly and cumbersome to administer and enforce, may be beyond practical capabilities of RWQCB.

Discussion

The threat of this alternative might provide impetus for implementation of Alternatives 1, 2 or 3. Fear of loss of local government control over land use decisions might prompt city councils and boards of supervisors to more aggressively push for implementation of BMPs. (The first paragraph under Alternative 3 "Discussion" also applies here.)

CONCLUSION

The four alternatives appear in ascending order of severity. The choice of alternative must depend on:

1) Severity of problem
2) Knowledge of ability of control measures to solve it
3) Local commitment to solve problem

The watershed case studies should answer points (1) and (2). If the problems are serious and the effectiveness of the control measures are known with reasonable certainty, then Alternative 1 should not be used--the plan should not be voluntary. Probably the most effective way to make the plan work is to make the carrot bigger than the stick. For example, copious cost-sharing monies should be aggressively sought. Ample assistance should be made available to land owners to help them qualify for it. Cost sharing for BMPs that will result in both private profit and public benefit should be encouraged.

Local and regional regulatory agencies must make it clear to property owners in problem areas that if voluntary actions are not adequate to solve the problem, regulatory action is certain to follow. Those agencies must express a clear commitment to solve the problem. Otherwise, they will not be taken seriously and private action will be minimal.

Alternative 2 is desirable because it assesses the costs of cleaning up the problem to those who create it. Thus there is a built-in incentive to implement. This Alternative, however, cannot succeed without a strong threat of Alternatives 3 or 4 being adopted in place of it.

WQ Issue Paper No. 7
P. Russell

SELECTION OF DESIGN STORM FOR

EROSION CONTROL

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This issue paper summarizes the maximum rain intensity ranges for the nine Bay Area counties. Information such as this is needed to rationally design stormwater handling facilities and select erosion prevention measures. Since rainfall intensity-sensitive activities developed to accommodate the average rainfall intensity would fail half the time, maximum intensities are selected whose likelihood of occurrence is appropriate to the damage caused by failure.

The table shows the ranges of maximum rainfall expected for 6-hour and 24-hour storms given recurrence intervals of 10 to 100 years. The ranges are tabulated separately for each of the nine Bay Area counties. Each range represents the spread in rainfall intensity values for that county reported in Rainfall Analysis for Drainage Design, California Department of Water Resources, Bulletin No. 195, October 1976. Some counties have broad ranges due to large climatological differences between different points within their borders, e.g., Santa Clara. Alternatively, other counties have more uniform rainfall intensity/duration/recurrence characteristics throughout, e.g., San Francisco.

To illustrate how rainfall intensity values are currectly selected from the table, suppose a sedimentation basin is to be designed to treat runoff from an erodible Napa County site. Further assume that the severity of downstream damages would be so great that the risk of hydraulic failure of the basin can be no greater than once every twenty five years. The entries under Napa County on the table show that for a twenty five year return period, a storm will likely occur that produces 3.58 to 4.16 inches of rainfall in 6 hours. It is equally likely that a storm will occur that produces 6.98 to 8.50 inches of rainfall over a 24 hour period. This may or may not be the same storm described by the 6 hour range. The sedimentation basin design should be adequate to accommodate either of these rainfall events, whichever is the worse case.

The values listed in the table serve to bracket the extremes found in each county. For a particular application, the data base cited above should be consulted to determine where, within the range of values given for the county, the rainfall intensity/duration/recurrence relationship characteristic of the site lies.

Maximum Rainfall Intensities in San Francisco Bay Area

Return Period	Maximum Precipitation in Inches for Indicated Duration 6 hour	24 hour
	Alameda County	
10 yr.	1.35 - 2.65	2.59 - 5.02
25 yr.	1.63 - 3.18	3.11 - 6.04
50 yr.	1.83 - 3.57	3.49 - 6.77
100 yr.	2.02 - 3.95	3.86 - 7.49
	Contra Costa County	
10 yr.	1.89 - 3.27	3.40 - 6.16
25 yr.	2.24 - 3.93	4.04 - 7.40
50 yr.	2.50 - 4.41	4.50 - 8.30
100 yr.	2.75 - 4.88	4.95 - 9.18
	Marin County	
10 yr.	1.65 - 3.73	2.64 - 6.91
25 yr.	1.99 - 4.48	3.17 - 8.30
50 yr.	2.23 - 5.02	3.55 - 9.32
100 yr.	2.46 - 5.55	3.93 - 10.30
	Napa County	
10 yr.	3.01 - 3.46	5.81 - 7.07
25 yr.	3.58 - 4.16	6.98 - 8.50
50 yr.	3.99 - 4.66	7.83 - 9.53
100 yr.	4.38 - 5.16	8.66 - 10.54
	San Francisco	
10 yr.	1.66 - 1.96	2.62 - 3.29
25 yr.	1.99 - 2.35	3.15 - 3.95
50 yr.	2.24 - 2.63	3.54 - 4.43
100 yr.	2.47 - 2.91	3.91 - 4.90

Return Period	Maximum Precipitation in Inches for Indicated Duration: 6 hour	24 hour
	San Mateo County	
10 yr.	1.53 - 2.78	2.46 - 5.23
25 yr.	1.84 - 3.34	2.96 - 6.29
50 yr.	2.07 - 3.75	3.32 - 7.05
100 yr.	2.29 - 4.15	3.67 - 7.80
	Santa Clara County	
10 yr.	1.18 - 4.07	2.04 - 8.95
25 yr.	1.42 - 4.89	2.45 - 10.75
50 yr.	1.59 - 5.49	2.75 - 12.06
100 yr.	1.76 - 6.07	3.04 - 13.33
	Solano County	
10 yr.	1.95	3.49
25 yr.	2.35	4.19
50 yr.	2.63	4.70
100 yr.	2.91	5.19
	Sonoma County	
10 yr.	1.99 - 4.02	3.54 - 9.00
25 yr.	2.39 - 4.72	4.25 - 10.55
50 yr.	2.68 - 5.22	4.76 - 11.67
100 yr.	2.96 - 5.70	5.27 - 12.75